California Environmental Protection Agency

AIR RESOURCES BOARD

Monitoring and Laboratory Division

Technical Support Document:

Small Off-Road Engine Validation Study and E10 Test Results

September 27, 2016

Table of Contents

List of Tables

Attachment

I. SUMMARY

The Air Resources Board (ARB) adopted regulations in September 2003 to control evaporative emissions of reactive organic gases (ROG) from spark-ignited small off-road engines (SORE). The regulations allowed two options for certifying SORE evaporative emission control systems: In the first, known as performance certification, an assembled engine is tested to ensure its diurnal emissions are below the diurnal emission standard. In the second, known as design certification, the evaporative emission control system is assembled using a fuel tank, fuel lines, and a carbon canister that are individually certified to meet design standards. In design certification, diurnal emissions are assumed to be below the diurnal emission standard, but they are not measured for certification. This was the first ARB program with a design certification option for evaporative emissions control systems. As a result, the SORE regulations incorporated two validation studies to give ARB the means to assess the effectiveness of the two certification options.

ARB is currently proposing amendments to the SORE evaporative emission regulations. Included in the proposed amendments is a requirement to perform SORE evaporative emissions testing using fuel containing 10 percent ethanol (referred to as E10 fuel). To assess the ability of SORE from recent model years to meet the current diurnal emission standards with E10 fuel, ARB staff purchased SORE equipment from several retail stores in the Sacramento, California area. The equipment was subsequently tested for evaporative emissions using E10 fuel. Several pieces of equipment from the validation studies, which were originally tested with the current certification test fuel that does not contain ethanol, were also tested with E10 fuel as part of the assessment.

This document presents the results for the SORE validation studies and the E10 fuel assessment. The first validation study was conducted on model year 2008-2010 equipment. In total, 30 units of equipment were tested: 20 by ARB and 10 by independent laboratories. Each unit underwent three diurnal emissions tests. Eighty percent of the units tested by ARB failed to meet the applicable diurnal emissions standard in at least 1 of 3 diurnal emissions tests. Twenty percent of the units tested by independent laboratories failed to meet the applicable diurnal emission standard in at least one of three diurnal emissions tests. The second validation study was conducted on model year 2013-2015 equipment. In total, 29 units of equipment were tested: 21 by ARB and 8 by independent laboratories. Each of these units also underwent three diurnal emissions tests. Fifty-two percent of the units tested by ARB failed to meet the applicable diurnal emission standard in at least one of three diurnal emissions tests. Fifty percent of the units tested by independent laboratories failed to meet the applicable diurnal emissions standard in at least one of three diurnal emissions tests. The validation study results were surprising due to both the high failure rate of the equipment tested and the difference in failure rate between equipment tested by ARB and that tested by independent laboratories.

In light of the overall high rates of non-compliance observed in both validation studies, ARB staff believes the design certification option for SORE must undergo significant change in order to maintain the availability and viability of this certification option going forward. Results from the two SORE validation studies also indicate a disparity between applicant-submitted certification data and ARB's data for the same evaporative families. The validation study results show greater than 50 percent of the SORE units tested fail to meet ARB's diurnal emission standard, even though manufacturer-submitted certification data show a 100 percent passing rate.

To date, a total of 22 SORE units have been tested with E10 fuel, 11 of which are performance-certified units. Six units were design-certified and were also tested in the validation studies, and five units were equipped with engines with displacement less than or equal to 80 cc. Of the 17 combined performance- and design-certified units tested for which there is currently a diurnal emission standard, 13 units met their respective standards. There is no diurnal emission standard for engines with displacement less than or equal to 80 cc, so the units with those engines were tested for informational purposes and their diurnal emissions were compared to the standards for engines with displacement greater than 80 cc and less than 225 cc. All five of these units had diurnal emissions below the diurnal emission standards for engines with displacement greater than 80 cc and less than 225 cc.

II. INTRODUCTION

Small off-road engines (SORE) are spark-ignited and rated at or below 19 kilowatts (25 horsepower). SORE are used to power a broad range of lawn and garden equipment including lawn mowers, leaf blowers, and lawn tractors, as well as generators. Evaporative emissions from gasoline-powered SORE are a significant source of ROG emissions, which are also precursors for ground-level ozone formation. As a result, SORE emissions impact California's air quality and public health negatively by contributing to nonattainment of both federal and State ambient air quality standards for ozone.

The first ARB evaporative emission standards for SORE were adopted in 2003. The regulations allowed both performance and design certification options for certifying SORE evaporative emission control systems. Because design certification was a new option, the regulations included two validation studies to assess its effectiveness. The validation studies were conducted for model years 2008 through 2010, and model years 2013 through 2015, as summarized in Table II-1. The timing of the validation studies was chosen to provide information early in the implementation of the regulations and again several years later. All SORE units selected for the validation studies were tested for evaporative emissions using a sealed housing for evaporative emissions determination (SHED), regardless of their certification method. However, more design-certified units were tested because design-certified evaporative families were not SHED-tested for certification.

ARB is currently proposing amendments to the SORE evaporative emission regulations. Included in the proposed amendments is a requirement to perform SORE evaporative emissions testing using fuel containing 10 percent ethanol (E10 fuel). To assess the ability of SORE from recent model years to meet the current diurnal emission standards with E10 fuel, ARB performed evaporative emissions testing on 22 SORE equipment units in its Sacramento SHED facility. The results of those tests are presented in this report.

Table II-1. Test Units by Model Year for the Validation Studies

Model Year	Number of Performance-Certified Units	Number of Design-Certified Units
2008	3	15
2009	1	5
2010	1	5
2013	3	15
2014	1	5
2015	1	5

III. TEST METHODOLOGY

All design- and performance-certified SORE selected for the validation and E10 studies were tested according to ARB test procedure TP-902, *Test Procedure for Determining Diurnal Evaporative Emissions from Small Off-Road Engines and Equipment* (TP-902, included as Attachment 1). The durability demonstration in TP-902 was omitted from validation study and E10 testing. Validation study testing was conducted with Phase II Certification Fuel, and E10 testing was conducted with LEV III Certification Gasoline. Each unit was subjected to three consecutive 24-hour diurnal emission tests in a SHED. For SORE employing a carbon canister as part of its evaporative emissions control system, the carbon canister was purged with 400 bed volumes of nitrogen gas immediately before SHED testing.

IV. TEST RESULTS

Validation study test results are summarized in Tables IV-1 and IV-2. The first validation study was conducted on model year 2008-2010 equipment. In total, 30 units of equipment were tested: 20 by ARB and 10 by independent laboratories. Each unit underwent three diurnal emissions tests. Eighty percent of the units tested by ARB failed to meet the applicable diurnal emissions standard in at least one of three diurnal emissions tests. Twenty percent of the units tested by independent laboratories failed to meet the applicable diurnal emission standard in at least one of three diurnal emissions tests. The second validation study was conducted on model year 2013-2015 equipment. In total, 29 units of equipment were tested: 21 by ARB and 8 by independent laboratories. Each of these units also underwent three diurnal emissions tests. Fifty-two percent of the units tested by ARB failed to meet the applicable diurnal emission standard in at least one of three diurnal emissions tests. Fifty percent of the units tested by independent laboratories failed to meet the applicable diurnal emissions standard in at least one of three diurnal emissions tests. The validation study results were surprising due to both the high failure rate of the equipment tested and the difference in failure rate between equipment tested by ARB and that tested by independent laboratories.

Results for the evaporative emissions tests performed using E10 fuel are summarized in Table IV-3. Of the 17 units in this study for which there is currently a diurnal emission standard, 13 units met their respective standards. Six of the 11 performance-certified units were walk-behind mowers, and all six met the diurnal emission standards. The other five performance-certified units were other equipment types, and four of these met the diurnal emission standards. Of the six design-certified units tested, three met the diurnal emission standards, and three exceeded their standards.

There is no diurnal emission standard for engines with displacement less than or equal to 80 cc, so the five units with those engines were tested for informational purposes and their diurnal emissions were compared to the standards for engines with displacement greater than 80 cc and less than 225 cc. All five of these units had diurnal emissions below the diurnal emission standards for engines with displacement greater than 80 cc and less than 225 cc.

Table IV-1. SORE Validation Study Results for Model Years 2008-2010

Model Year	Engine Number	Evaporative Emissions Executive Order Holder	Equipment Brand	Equipment Model	Engine Manufacturer	Engine Family	Engine Displacement (cc)	Equipment Description	Nominal Fuel Tank Capacity (L)	Evaporative Emissions Family and Executive Order Number	Test Facility	24-hour Diurnal Result (g/day)	24-hour Diurnal Result Standard Deviation	Relative Standard Deviation	24-hour Diurnal Performance Standard (g/day)	Evaporative Family Emission Limit Differential (g/day)	Evaporative Model Emission Limit (g/day)	Certification Level (g/day)	Certification Option	Emission Control systems: Venting Control Type	Emission Control systems: Tank Barrier Type	Emission Control systems: Exhaust	Fuel Hose Manufacturer	Fuel Hose Permeation Standard (g ROG/m^2/day): Standard	Fuel Hose Permeation Standard (g ROG/m^2/day): Fuel Hose Certification Level or EO	Fuel Tank Manufacturer	Fuel Tank Permeation Standard (g ROG/m^2/day): Standard	Fuel Tank Permeation Standard (g ROG/m^2/day): Certification Level or EO	Carbon Canister Manufacturer	Carbon Canister Butane Working Capacity (g HC/L): Standard	Carbon Canister Butane Working Capacity (g HC/L): Certification Level or EO	Carbon Canister Working Capacity (g)
2008	1 (8P1)	Honda Motor Co., Ltd.	Honda	HRR216PDA	Honda Motor Co., Ltd.	7HNXS.187A1A	187	Walk-Behind Mower	0.91	CPHNXW1B U-U-001-0345	ARB	1.230 1.690 1.540	0.23	0.16	1.30	-0.50	1.80	1.53	Performance					15						1.0		
	2 (8D1)	John Deere	John Deere	LA 115	Briggs & Stratton Corporation	8BSXS.5002VV	500	Tractor	9.5	CO U-U-077-0008	ARB	0.890 0.910 1.120	0.13	0.13	1.732				Design	Canister	Other		Mark IV Automotive; Mold-Ex Division of SETi Inc.; Avon Automotive; Mark IV Automotive; Mark IV Automotive; Mold-Ex Division of SETi Inc.; Avon Automotive	15	7 (C-U-05-002) 7 (C-U-05-011) 2 (C-U-05-013) 7 (C-U-06-030) 5 (G-05-016) 8 (G-05-017A) 9 (G-05-018)	Centro Inc.	2.5	0.75 C-U-06-028	Miniature Precision Components	1.4	3 C-U-06-015	28.1
	3 (8D15)	Standard Technologies	Standard Technologies	RVQG4000	Cummins Power Generation	8N5XS.3042GG	304	Generator/ Refueling Tank	113.56	CM1035S U-U-148-0003	ARB	6.520 6.383 6.172	0.175	0.028	7.559				Design	Canister	Metal		Avon Automotive	15	9 G-05-018		2.5		Delphi Powertrain	1.4	1.7 Q-07-016	196.5
	4 (8P2)	Kawasaki Heavy Industries, Ltd.	The Toro Company	FJ180	Kawasaki Heavy Industries, Ltd.	8KAXS.1791DA	179	Walk-Behind Mower	1.6	8KAXS.1791OP U-U-004-0354-1	ARB	1.360 1.450 1.350	0.06	0.04	1.30	0.30	1.00	0.99	Performance	Other	Treated HDPE		Avon Automotive; Mold-Ex Division of SETi Inc.	15	9 (G-05-018) 8 (G-05-017A)					1.0		
	5 (8P3)	Briggs & Stratton Corporation	Weedeater		Briggs & Stratton Corporation	8BSXS.1581VX	148	Walk-Behind Mower	0.84	CMV1 U-U-002-0447	ARB	3.190 5.290 15.070	6.34	0.81	1.25	0.10	1.15	0.90	Performance	Canister	Metal			15						1.0		
	6 (8D2)	Yancheng Jiangdong Gasoline engine Manufacturing Co., Ltd.		JF 120	Yancheng Jiangdong Gasoline engine Manufacturing Co., Ltd.	8YJGS.1181YC	118	Compressor	2.6	CM U-U-129-0014-2	ARB	4.250 2.630 1.900	1.20	0.41	1.35				Design	Canister	Metal	TWC	Mold-Ex Division of SETi Inc.; Hangzhou Rewin Vehicle Parts Co., Ltd; Tsu Tah Elastomerics Co., Ltd.	15	8 (G-05-017), 4 (Q-08-005), 9 (C-U-05-012)		2.5		Sentec E&E Co., Ltd.; Hangzhou Rewin Vehicle Parts Co., Ltd.	1.0	1.6 (C-U-06-003) 1.6 (C-U-07-008)	4.1 4.05
	7 (8D3)	John Deere	John Deere	TX Gator	Kawasaki Heavy Industries, Ltd.	8KAXS.4012CC	401	Utility Vehicle	18.9	CC U-U-077-0006-1	ARB	2.940 2.260 3.750	0.75	0.25	2.26				Design	Canister	Coextruded		Avon Automotive; Marugo Rubber Industries, Ltd.; Mold-Ex Division of SETi Inc.; Avon Automotive; Mold-Ex Division of SETi Inc.	15	9 (G-05-018), 14 (C-U-05-006), 7 (C-U-05-011), 2 (C-U-05-013), 8 (G-05-017A)		2.5		Miniature Precision Components	1.4	1.5 C-U-06-015	28.1
	8 (8D4)	Jiangsu Changfa Group		CFQ168F-1	Jiangsu Changfa Group	8JCGS.1961CA		Compressor	3.6	8JCGSECM1GAC U-U-149-0006	ARB	2.940 3.600 2.380	0.61	0.21	1.40				Design	Canister	Metal		Avon Automotive	15	9 G-05-018		2.5		Sentec E&E Co., Ltd.	1.0	2.8 C-U-06-031	10.2
	9 (8D5)	United Power Equipment Co., Ltd.		UP168	United Power Equipment Co., Ltd.	8UPMS.1961CA	196	Pressure Washer	3.6	CM U-U-125-0014	ARB	1.820 1.890 2.030	0.11	0.06	1.40				Design	Canister	Metal	TWC	Tsu Tah Elastomerics; Avon Automotive	15	9 (C-U-05-012) 9 (G-05-018)		2.5		Sentec E&E Co., Ltd.; Hangzhou Rewin Vehicle Parts Co., Ltd.	1.0	1.1 (C-U-06-003) 1.1 (C-U-07-008)	4.1 4.05
	10 (8D6)	Briggs & Stratton Corporation	Husqvarna	LGT2654	Briggs & Stratton Corporation	8BSXS.7242VA	724	Riding Mower	15		ARB	1.950 1.970 2.110	0.087	0.043	2.04				Design					15				Small Volume Exemption		1.4		
	11 (8D7)	Homelite Consumer Products, Inc.	Homelite	HU40181A	Fuji Heavy Industries, Ltd.	8FJXS.1261SA	126	Generator	5.69	CM8HCP3 U-U-060-0049-2	ARB	3.890 3.470 6.160	1.447	0.321	1.52				Design	Canister	Metal		Parker Hannifin Corporation; Parker Hannifin Corporation; Mark IV Automotive; Mold-Ex Division of SETi Inc.; Avon Automotive	15	6 (C-U-06-010) 6 (C-U-06-016) 5 (G-05-016) 8 (G-05-017A) 9 (G-05-018)		2.5		Sentec E&E Co., Ltd.	1.4	1.8 C-U-06-031	10.2
	12 (8D8)	Chongqing Huawei Lianlong Science & Technology Co., Ltd.		LL170F	Chongqing Huawei Lianlong Science & Technology Co., Ltd.	8CHLS.2151LL	197	Pressure Washer	3.6	CM U-U-144-0002	ARB	1.660 2.450 2.600	0.51	0.23	1.402				Design	Canister	Metal		Tsu Tah Elastomerics	15	9 C-U-05-012		2.5		Sentec E&E Co., Ltd.; Hangzhou Rewin Vehicle Parts Co., Ltd.	1.0	1.1 (C-U-06-003) 1.1 (C-U-07-008)	4.1 4.05
	13 (8D9)	Liquid Combustion Technology Inc.	Liquid Combustion Technology		Liquid Combustion Technology Inc.	8LCTS.196L5A	208	Engine	3.6	8LCTE1CM196L U-U-063-0013	ARB	2.050 2.520 2.120	0.254	0.114	1.402				Design	Canister	Metal		Mold-Ex Division of SETi Inc.; Mark IV Automotive	15	8 (G-05-017A) 7 (C-U-06-030)		2.5		Sentec E&E Co., Ltd.	1.0	1.1 C-U-06-003	4.1
	14 (8D10)	Briggs & Stratton Corporation	Craftsman		Briggs & Stratton Corporation	8BSXS.2051HD	205	Pressure Washer	3.69	CMH1 U-U-002-0479	ARB	2.430 1.910 2.160	0.26	0.12	1.407				Design	Canister	Metal		Mark IV Automotive; Mold-Ex Division of SETi Inc.; Avon Automotive	15	5 (G-05-016) 8 (G-05-017A) 9 (G-05-018)		2.5		Sentec E&E Co., Ltd.	1.0	1.1 C-U-06-003	4.1
	15 (8D11)	Zhejiang Robot Power Machinery Co., Ltd.		168F		8ZHRS.1961NL	196	Generator	15	CM U-U-116-0012	ARB	38.540 31.316 44.010	6.367	0.168	2.040				Design	Canister	Metal		Tsu Tah Elastomerics; Hangzhou Rewin Vehicle Parts Co., Ltd.	15	9 (C-U-05-012) 4 (Q-08-005)		2.5		Sentec E&E Co., Ltd.; Hangzhou Rewin Vehicle Parts Co., Ltd.	1.4	1.6 (C-U-06-007) 1.7 (C-U-07-009)	23.7 25.69
	16 (8D12)	Kawasaki Heavy Industries, Ltd.		FE120	Kawasaki Heavy Industries, Ltd.	8KAXZ.1241DA	124	Generator	2.6	8KAXZ.1241CM U-U-004-0353	ARB	2.554 1.908 1.805	0.406	0.194	1.3				Design	Canister	Metal		Marugo Rubber Industries, Ltd.	15	14 C-U-05-006		2.5		Sentec E&E Co., Ltd.	1.0	1.6 C-U-06-003	4.1
	17 (8D13)	Shandong Huasheng Zhongtian Machinery Group Co., Ltd.		168F	Shandong Huasheng Zhongtian Machinery Group Co., Ltd.	8SHSS.1631GA	163	Generator	3.6	CM U-U-118-0024-1	ARB	1.774 2.562 2.023	0.403	0.190	1.402				Design	Canister	Metal		Tsu Tah Elastomerics; Avon Automotive; Hangzhou Rewin Vehicle Parts Co., Ltd.	15	9 (C-U-05-012) 9 (G-05-018) 2 (Q-08-004) 4 (Q-08-005)		2.5		Sentec E&E Co., Ltd.; Hangzhou Rewin Vehicle Parts Co., Ltd.	1.0	1.1 (C-U-06-003) 1.1 (C-U-07-008)	4.1 4.05
	18 (8D14)	Club Car, Inc.	Club Car	Carryall 1	Kawasaki Heavy Industries, Ltd.	7KAXS.4012CA	401	Utility Vehicle	19.15	UTL.01CP U-U-076-0014	ARB	0.889 3.130 10.133	4.822	1.022	2.2724				Design	Canister	Treated HDPE		Mark IV Automotive; Avon Automotive	15	5 (G-05-016) 9 (G-05-018)	The Plastics Group	2.5	1.1 C-U-07-027	Sentec E&E Co., Ltd.	1.4	2 C-U-06-009	37.6
2009	19 (9D1)	Kawasaki Heavy Industries, Ltd.			Kawasaki Heavy Industries, Ltd.	8KAXS.6172IB	617	Off-Road Utility Vehicle	23.5	9KAXS.6172CP U-U-004-0371		0.54 0.45 0.62	0.0850	0.1585	2.516				Design	Canister	Metal		Nitta Moore Company	15	0.4 Q-08-008	Kawasaki Motors Corp., USA	2.5	0.21 Q-08-014	Sentec E&E Co., Ltd.	1.4	1.7 C-U-07-016	38.8
	20 (9D2)	Lifan Industry (Group) Co., Ltd.		190F	Lifan Industry (Group) Co., Ltd.	9CLGS.4209OF	420	Compressor	6.5	CM6 U-U-074-0042-2		1.28 1.10 1.28	0.104	0.085	1.564				Design	Canister	Metal		Tsu Tah Elastomerics; Hangzhou Rewin Vehicle Parts Co., Ltd.; Wenzhou Depurate Environmental Three-way Catalyst Co., Ltd.	15	9 (C-U-05-012) 4 (Q-08-005) 4 (Q-08-037)		2.5		Sentec E&E Co., Ltd.; Hangzhou Rewin Vehicle Parts Co., Ltd.; Wenzhou Depurate Environmental Three-way Catalyst Co., Ltd.	1.4	1.6 (C-U-06-031) 1.7 (C-U-07-021) 1.7 (Q-08-035)	10.2 10.92 10.97
	21 (9D3)	Loncin Industrial Co., Ltd.			Loncin Industrial Co., Ltd.	9GCPS.2702GC	270	Generator	6.3	U-U-145-0018-2		1.330 0.940 1.080	0.198	0.177	1.553			0.83	Design	Canister	Metal		Tsu Tah Elastomerics; Hangzhou Rewin Vehicle Parts Co., Ltd.; Sichuan Chuanhuan Technology Co., Inc.; Wenzhou Depurate Environmental Three-way Catalyst Co., Ltd.	15	9 (C-U-05-012) 4 (Q-08-005) 11 (Q-08-024) 4 (Q-08-037)		2.5		Sentec E&E Co., Ltd.; Hangzhou Rewin Vehicle Parts Co., Ltd.	1.4	1.6 (C-U-06-031) 1.7 (C-U-07-021)	10.2 10.92
	22 (9D5)	Yongkang Xingguang Electrical Manufacture Co., Ltd.	XG	XG-152F	Yongkang Xingguang Electrical Manufacture Co., Ltd.	9YKXS.1251XG	125	Generator	6	CM U-U-159-0006	National Motorcycle Quality Supervisory & Testing Center (Tianjin)	1.407 1.487 1.452	0.040	0.028	1.536				Design	Canister	Metal	TWC, PAIR	Tsu Tah Elastomerics; Hangzhou Rewin Vehicle Parts Co., Ltd	15	9 (C-U-05-012) 4 (Q-08-005)	Zhejiang Yongkang QILI Hardware Manufacture Co., Ltd.	2.5		Sentec E&E Co., Ltd.; Hangzhou Rewin Vehicle Parts Co., Ltd.	1.4	1.7 (C-U-06-031) 1.8 (C-U-07-021)	10.2 10.92
	23 (9P1)	Kohler Company		XT-7		9KHXS.1731GD	173	Walk-Behind Mower	1.3	CO U-U-005-0289	ARB	2.02 2.02 2.22			1.00			0.93	Performance	Canister	Other (Xenoy)		Tsu Tah Elastomerics; Hangzhou Rewin Vehicle Parts Co., Ltd	15	9 (C-U-05-012) 2 (Q-08-004) 4 (Q-08-005)	SABIC Innovative Plastics		0.40 C-U-07-007a		1.0		
	24 (9D4)	Chongqing Rato Power Co., Ltd.		RV160	Chongqing Rato Power Co., Ltd.	9CRPS.1631RV	163	Pressure Washer	1.0	CO163V U-U-169-0014-1		0.750 1.190 3.370			1.256				Design	Canister	Other (Xenoy)	TWC, PAIR	Tsu Tah Elastomerics; Hangzhou Rewin Vehicle Parts Co., Ltd.; Sichuan Chuanhuan Technology Co., Inc.	15	9 (C-U-05-012) 4 (Q-08-005) 3 (Q-08-017)	SABIC Innovative Plastics	2.5	0.40 Q-08-006	Sentec E&E Co., Ltd.; Hangzhou Rewin Vehicle Parts Co., Ltd.; Wenzhou Depurate Environmental Three-way Catalyst Co., Ltd.	1.0	4.1 (C-U-06-003) 4.1 (C-U-07-008) 4 (Q-07-020)	4.1 4.05 4.00
2010	25 (10P1)	Honda Motor Co., Ltd.	Honda	GXV160	Honda Motor Co., Ltd.	AHNXS.1631AZ	163	Walk-Behind Mower	1.4	CPHNXW2A U-U-001-0494	ARB	0.89 1.11 1.16	0.14	0.14	1.00	-0.30	1.30	1.1	Performance	Canister	Treated HDPE			15						1.0		
	26 (10D1)	Fuji Heavy Industries Ltd.	Subaru	RGX2900 EX17	Fuji Heavy Industries Ltd.	AFJXS.1691GW	169	Generator	15.4	CM2 U-U-012-0339-1	TSG	0.465 0.650 1.120	0.337	0.453	2.062				Design	Canister	Metal		Kokoku Rubber, Inc.; Avon Automotive	15	13 (C-U-05-003) 9 (G-05-018)		2.5			1.4	1.6	25.15
	27 (10D2)	Fuji Heavy Industries Ltd.	Subaru	RGX3600	Fuji Heavy Industries Ltd.	AFJXS.2111GW	211	Generator	15.4	CM3 U-U-012-0343-1	TSG	0.496 1.053 1.261	0.396	0.422	2.06				Design	Canister	Treated HDPE		Kokoku Rubber, Inc.; Avon Automotive	15	13 (C-U-05-003) 9 (G-05-018)		2.5			1.4	1.6	25.15
	28 (10D3)	Denyo Co., Ltd.		GA-3.6HA	Honda Motor Co., Ltd.	AHNXS.2702AA	270	Generator	19	CMH3 U-U-127-0022		0.73 0.76 0.69			2.26				Design	Canister	Metal		Kokoku Rubber, Inc.	15	13 (C-U-05-003) 11 (C-U-06-017)		2.5		Sentec E&E Co., Ltd.	1.4	2 C-U-07-016	38.8
	29 (10D5)	Kawasaki Heavy Industries, Ltd.	Mule	KAF620R/S/P/M/ N-255	Kawasaki Heavy Industries, Ltd.	AKAXS.6172IB	617	Engine (for Off-Road Utility Vehicle)	23.5	AKAXS.6172CP U-U-004-0409	Kawasaki Heavy Industries, Ltd. (Japan)	0.454 0.902 0.924	0.266	0.349	2.52				Design	Canister	Metal		Nitta Moore Company	15	0.4 Q-08-008	Kawasaki Motors Corp., USA	2.5	0.21 Q-08-014	Sentec E&E Co., Ltd.	1.4	1.7 C-U-07-016	38.8
	30 (10D4)	Denyo Co., Ltd.		GA-6HA	Honda Motor Co., Ltd.	AHNXS.3892AA	389	Generator	19	CMH4 U-U-127-0023		2.46 2.16 2.43			2.264				Design	Canister	Metal		Kokoku Rubber, Inc.	15	13 (C-U-05-003) 11 (C-U-06-017)		2.5		Sentec E&E Co., Ltd.	1.4	2 (C-U-07-016) 1.2 (C-U-06-007)	38.8 23.7

Table IV-2. SORE Validation Study Results for Model Years 2013-2015

Model Year	Engine Number	Evaporative Emissions Executive Order Holder	Equipment Brand	Equipment Model	Engine Manufacturer	Engine Family	Engine Displacement (cc)	Equipment Description	Nominal Fuel Tank Capacity (L)	Evaporative Emissions Family and Executive Order Number	Test Facility	24-hour Diurnal Result (g/day)	24-hour Diurnal Result Standard Deviation	Relative Standard Deviation	24-hour Diurnal Performance Standard (g/day)	Evaporative Family Emission Limit Differential (g/day)	Evaporative Model Emission Limit (g/day)	Certification Level (g/day)	Certification Option	Emission Control systems			Fuel Hose Manufacturer	Fuel Hose Permeation Standard (g ROG/m^2/day)		Fuel Tank Manufacturer	Fuel Tank Permeation Standard (g ROG/m^2/day)		Carbon Canister Manufacturer	Carbon Canister Butane Working Capacity (g HC/L)		Carbon Canister Working Capacity (g)
																				Venting Control Type	Tank Barrier Type	Exhaust		Standard	Fuel Hose Certification Level or EO		Standard	Certification Level or EO		Standard	Certification Level or EO	
2013	1 (13D8)	Kubota Corporation	Kubota Corporation	T1880	Kohler Company	DKHXS.5972GB	597	Tractor	16	CO3 U-U-003-0234	ARB	1.263 1.562 1.448	0.15	0.11	2.096				Design	Canister	Other		Avon Automotive	15	9 G-05-018		1.5	small production volume exemption	Miniature Precision Components	1.4	1.8 Q-07-009	28.09
2013	2 (13D13)	John Deere	John Deere	X300	Kawasaki Heavy Industries, Ltd.	DKAXS.6032CA	603	Tractor	12.5	CC1 U-U-077-0039-4	ARB	1.214 1.344 1.515	0.15	0.11	1.9				Design	Canister	Coextruded		Avon Automotive	15	9 G-05-018		1.5		Miniature Precision Components	1.4	2.2 C-U-06-015	28.1
2013	3 (13D9)	The Toro Company	The Toro Company	Titan ZX4820	Kawasaki Heavy Industries, Ltd.	CKAXS.7262CB	726	0-Turn Riding Mower	22.7	CCDL4XBU U-U-052-0115	ARB	0.634 0.658 0.643	0.012	0.019	2.471				Design	Canister	Coextruded		Avon Automotive; PML, Inc.	15	9 (G-05-018), 14 (C-U-05-006)		1.5		Sentec E&E Co., Ltd.	1.4	2.4 Q-08-031	54.8
2013	4 (13D10)	United Power Equipment Co., Ltd.	Generac Centurion by Generac Power Systems, Inc.	GP3250	United Power Equipment Co., Ltd.	DUPMS.2081CB	208	Generator	15	CM5 U-U-125-0078	ARB	0.938 0.91 0.853	0.043	0.048	1.79				Design	Canister	Metal	TWC, PAIR	Hangzhou Rewin Vehicle Parts Co., Ltd	15	4 Q-08-005		1.5		Miniature Precision Components	1.4	1.7 C-U-07-009	25.69
2013	5 (13D2)	Excel Industries	Hustler (Excel Industries, Inc.)	930123US	Kawasaki Heavy Industries, Ltd.	DKAXS.7262CC	726	0-Turn Riding Mower	29.19	CNEXCSD U-U-099-0037	ARB	2.801 1.955 2.237	0.43	0.18	2.835				Design	Canister	Nylon		Parker Hannifin Corporation; Avon Automotive	15	12 (Q-08-013), 9 (G-05-018)		1.5	small production volume exemption	Flex Technologies	1.4	1.7 Q-09-023	49.48
2013	6 (13D17)	Techtronic Industries North America, Inc.	Gravely (Ariens)	986052 (7500 W)	Honda Motor Co., Ltd.	DHNXS.3892AB	389	Generator	30.3	CM8HCP4 U-U-060-0204-1	ARB	2.216 2.324 2.382	0.084	0.037	2.897				Design	Canister	Metal		Parker Hannifin Corporation	15	6 (C-U-06-010)		1.5		Sentec E&E Co., Ltd.	1.4	2.1 C-U-07-011	64.5
2013	7 (13D12)	Lifan Industry (Group) Co., Ltd.	Lifan	Energy Storm 8000E	Lifan Industry (Group) Co., Ltd.	DCLGS.4202CA	420	Generator	25	CM6 U-U-074-0124-1	ARB	1.092 1.078 1.2	0.067	0.059	2.6				Design	Canister	Metal		Avon Automotive; Wenzhou Depurate Environmental Three-way Catalyst Co., Ltd.; Hangzhou Rewin Vehicle Parts Co., Ltd; Tsu Tah Elastomerics	15	9 (G-05-018), 4 (Q-08-037), 4 (Q-08-005), 9 (C-U-05-012)		1.5		Sentec E&E Co., Ltd.	1.4	1.6 C-U-07-016	38.8
2013	8 (13D19)	Briggs & Stratton Corporation	Snapper (Briggs & Stratton Corporation)	7800932-00	Briggs & Stratton Corporation	DBSXS.3442VA	344	Riding Mower	7.4	CMG1 U-U-002-0785-1	ARB	0.863* 1.258* 1.284*	0.24	0.21	1.614				Design	Canister	Metal		Avon Automotive	15	9 G-05-018		1.5		Sentec E&E Co., Ltd.	1.4	1.4 C-U-06-031	10.2
2013	9 (13P2)	Chongqing Rato Power Manufacturing Corporation	Chongqing Rato	R180-3-III	Chongqing Rato Power Manufacturing Corporation	DCRPS.1791GA	179	Walk-Behind Mower	3.4	OM1H U-U-169-0086-1	ARB	1.297 1.719 1.497	0.21	0.14	1.00			0.83	Performance	Other	Metal		Tsu Tah Elastomerics	15	9 C-U-05-012							
2013	10 (13P3)	Kohler Company	The Toro Company	22in Recycler (XT6.75 engine)	Kohler Company	DKHXS.1491GB	149	Walk-Behind Mower	1	CO2 U-U-005-0382	ARB	1.282 1.381 1.34	0.050	0.037	1.00			0.8	Performance	Canister	Other		Avon Automotive	15	9 G-05-018							
2013	11 (13P1)	Honda Motor Co., Ltd.	Honda	GCV160	Honda Motor Co., Ltd.	DHNXS.1871AA	160	Walk-Behind Mower	0.91	CCHNXW1B U-U-001-0610	ARB	1.29 1.364 1.342	0.038	0.029	1.00	-0.35	1.35	1.17	Performance	Canister	Coextruded		Kokoku Rubber, Inc.	15	14 Q-07-018							
2013	12 (13D5)	Denyo Co., Ltd.	Multiquip	MQ GA-2.5H	Honda Motor Co., Ltd.	CHNXS.1631AB	163	Generator	12	CMH1 U-U-127-0038-1	ARB	2.004 2.315 2.241	0.16	0.07	1.622				Design	Canister	Metal		Kokoku Rubber, Inc.	15	14 Q-07-018		1.5		Sentec E&E Co., Ltd.	1.4	2 C-U-06-007	23.7
2013	13 (13D3)	Briggs & Stratton Corporation	Snapper (Briggs & Stratton Corporation)	2691021	Briggs & Stratton Corporation	DBSXS.7242VA	656	Tractor	13.1	CPF4 U-U-002-0790-1	ARB	2.605 2.491 2.477	0.070	0.028	1.934				Design	Canister	Treated HDPE		Avon Automotive	15	9 G-05-018		1.5	0.5	Flex Technologies	1.4	1.6 Q-09-024	20.39
2013	14 (13D7)	Jiangsu Jiangdong Group Co., Ltd.	Gentron USA (All Power)	Pro 2 3500W-C	Jiangsu Jiangdong Group Co., Ltd.	DJDGS.2081GC	196	Generator	15	CM3 U-U-068-0090	ARB	1.614 1.827 1.929	0.16	0.09	1.79				Design	Canister	Metal		Hangzhou Rewin Vehicle Parts Co., Ltd	15	4 Q-08-005		1.5		Wenzhou Depurate Environmental Three-Way Catalyst Co, Ltd	1.4	1.7 Q-07-021	25.51
2013	15 (13D16)	Sunjoy (Fujian) Power Machinery Co., Ltd.	Sunjoy	154F	Sunjoy (Fujian) Power Machinery Co., Ltd.	DSNJS.0871SY	87	Generator	5.2	CM2 U-U-207-0012	ARB	5.91 5.355 4.069			1.241				Design	Canister	Metal		Hangzhou Rewin Vehicle Parts Co., Ltd	15	4 Q-08-005		1.5		Hangzhou Rewin Vehicle Parts Co. Ltd.	1.4	2.1 C-U-07-021	10.92
2013	16 (13D18)	Chongqing Am Pride Power & Machinery Co., Ltd.	A-iPower	SU8250E	Chongqing Am Pride Power & Machinery Co., Ltd.	DCPPS.4202GC	420	Generator	25	CM4202 U-U-164-0027	ARB	5.243 6.639 11.23			2.6				Design	Canister	Metal		Hangzhou Rewin Vehicle Parts Co., Ltd	15	4 Q-08-005		1.5		Wenzhou Depurate Environmental Three-Way Catalyst Co, Ltd	1.4	1.8 Q-08-036	46
2013	17 (13D15)	Jiangsu Tiger Yacht Manufacture Co., Ltd.	Power-Max Tiger	INF5000	Jiangsu Tiger Yacht Manufacture Co., Ltd.	DJTYS.3572GC	321	Generator	24	CM3572 U-U-206-0004	ARB	11.49 11.94 11.28			2.544				Design	Canister	Metal		Hangzhou Rewin Vehicle Parts Co., Ltd; Sichuan Chuanhuan Technology Co., Ltd.	15	4 (Q-08-005), 3 (Q-08-017)		1.5		Nanjing Depurate Catalyst Co., Ltd.	1.4	2 Q-13-005	48.75
2013	18 (13D4)	Chongqing Dinking Power Machinary Co., Ltd.	Dinking	DK1GF	Chongqing Dinking Power Machinary Co., Ltd.	DCHDS.0971DK	97	Generator	4	CM0971 U-U-210-0017-1	ARB	5.815 14.636 16.647			1.174				Design	Canister	Metal		Hangzhou Rewin Vehicle Parts Co., Ltd; Chongqing Yuanping Automotive Parts Co., Ltd.	15	4 (Q-08-005), 7 (Q-12-003)		1.5		Wenzhou Depurate Environmental Three-Way Catalyst Co, Ltd	1.4	2.7 Q-08-035	10.97
	* Unit was tested with LEV III Certification Gasoline containing 10% ethanol. Results have not been corrected for ethanol emissions.																															
2014	19 (14D2)	MTD Consumer Group, Inc.	Troy-Bilt	Mustang 50 17ARCACP211	Kohler Company	EKHXS.7252GB	725	Riding Mower, Tractor, Commercial Turf	10.67	CP1 U-U-130-0042-2	Sterling Performance Testing Services	1.258 1.268 1.267	0.0057	0.0045	1.798				Design	Canister	Treated HDPE		Avon Automotive	15	9 G-05-018	MTD Consumer Group Inc.	1.5	1.07 Q-11-011	Miniature Precision Components	1.4	2.6 C-U-06-015	28.1
2014	20 (14D4)	The Toro Company	The Toro Company	79549 Grandstand	Kawasaki Heavy Industries, Ltd.	DKAXS.7262CA	726	Riding Mower	32.3	CCEL4XBR U-U-052-0136	Roush Emissions Laboratory	0.245 0.308 0.333	0.046	0.154	3.009				Design	Canister	Coextruded		Avon Automotive	15	9 G-05-018		1.5		Delphi Powertrain	1.4	2.5 Q-07-013a	82.2
2014	21 (14P1)	Briggs & Stratton Corporation	Snapper	130G32-0021-F1	Briggs & Stratton	EBSXS.2081HB	208	Tiller	3.07	CMH3 U-U-002-0826	ARB	0.567 0.648 0.758	0.096	0.146	1.122			0.83	Performance	Canister	Metal		Goodwill Elastomerice Co., Ltd.	15	9 C-U-05-012							
2014	22 (14D1)	Club Car, LLC	Club Car	Carryall 500	Fuji Heavy Industries, Ltd.	EFJXS.4042GD	404	Utility Vehicle	21.0	CP.EXM01 U-U-076-0047	Automotive Testing and Development Services, Inc.	2.64 2.8 1.76	0.56	0.23	2.376				Design	Canister	Treated HDPE	TBI, ECM	Nobel Automotive	15	9 Q-08-020	Club Car, LLC	1.5	0.713 Q-13-020	Sentec E&E Co., Ltd.	1.4	1.8 C-U-07-016	38.8
2014	23 (14D3)	Wuxi Kipor Power Co., Ltd.	Kipor	KG205GETi	Wuxi Kipor Power Co., Ltd.	EWKPS.1961GC	196	Generator Set	11.5	CP1961 U-U-162-0095-1	National Motorcycle Quality Supervisory & Testing Center (Tianjin)	1.720 (14 hours) 3.799 4.654			1.594				Design	Canister	Treated HDPE	TWC, PAIR	Goodwill Elastomerice Co., Ltd.	15	9 C-U-05-012	Wuxi Kipor Power Co., Ltd.	1.5	1.21 Q-11-018	Sentec E&E Co., Ltd.	1.4	2.1 C-U-06-007	23.7
2014	24 (14D5)	Husqvarna Consumer Outdoor Products N.A. Inc.	Husqvarna	YT 42 LS 960430190 00	Kawasaki Heavy Industries, Ltd.	EKAXS.6032CC	603	Riding Mower	11.21	CP U-U-006-0483	ARB	5.854 5.453 5.608			1.828				Design	Canister	Treated HDPE		Avon Automotive	15	9 G-05-018	The Plastics Group	1.5	2.47 Q-07-019	Miniature Precision Components, Inc.	1.4	2.5 C-U-06-015	28.1
2015	25 (15D1)	Zhejiang Yaofeng Power Technology Co., Ltd.	Champion Power Equipment	46533	Zhejiang Yaofeng Power Technology Co., Ltd.	FZYPS.2241GA	196	Generator	14.2	CM1 U-U-220-0030-2	National Motorcycle Quality Supervisory & Testing Center (Tianjin)	1.722 1.201 1.425	0.26	0.18	1.745				Design	Canister	Metal		Hangzhou Rewin Vehicle Parts Co., Ltd	15	4 Q-08-005		1.5		Nanjing Depurate Catalyst Co., Ltd.	1.4	1.7 Q-13-004	24.36
2015	26 (15D2)	Loncin Motor Co., Ltd.	Predator	LC3500-C	Loncin Motor Co., Ltd.	FCGPS.2121GR	212	Generator	15	CMFCGPS.212 U-U-145-0164-1	National Motorcycle Quality Supervisory & Testing Center (Tianjin)	1.598 1.650 1.646	0.029	0.018	1.79				Design	Canister	Metal		Avon Automotive	15	9 G-05-018	Loncin Motor Co., Ltd.	1.5		Sentec E&E Co., Ltd.	1.4	1.6 C-U-06-007A	23.7
2015	27 (15P1)	Chongqing Zongshen General Power Machine Co., Ltd.	Yard Machines by MTD	5T65RUA	Chongqing Zongshen General Power Machine Co., Ltd..	FCZHS.1591V1	141	Walk-Behind Mower	0.78	CPCC U-U-082-0154	ARB	0.581 0.637 0.576	0.034	0.057	1.00			0.69	Performance	Canister	Treated HDPE		Avon Automotive	15	6 Q-14-008							
2015	28 (15D3)	Suzhou Zhonggu Mould Co., Ltd.	BOLIY	166F	Suzhou Zhonggu Mould Co., Ltd.	FSZZS.1711MD	171	Generator	7.0	CM U-U-186-0012	National Motorcycle Quality Supervisory & Testing Center (Tianjin)	4.474 0.523 0.55			1.342				Design	Canister	Metal	TWC, PAIR	Hangzhou Rewin Vehicle Parts Co., Ltd	15	4 Q-08-005	Suzhou Zhonggu Mould Co., Ltd.	1.5		Wenzhou Depurate Environmental Three-way Catalyst Co., Ltd.	1.4	1.6 Q-08-035	10.97
2015	29 (15D5)	Yongkang Xingguang Electrical Manufacture Co., Ltd.	Powerhouse	PH2100PRi XG152F	Yongkang Xingguang Electrical Manufacture Co., Ltd.	FYKXS.1251XG	125	Generator	4.9	CM U-U-159-0095	Tianjin Internal Combustion Engine Research Institute	1.223 1.131 1.240	0.059	0.049	1.224				Design	Canister	Metal	TWC, PAIR	Hangzhou Rewin Vehicle Parts Co., Ltd	15	4 Q-08-005		1.5		Hangzhou Rewin Vehicle Parts Co., Ltd.	1.4	2.2 C-U-07-021	10.92

Table IV-3. Test Results for Diurnal Emission Testing with E10 Fuel

Engine Number	Evaporative Emissions Executive Order Holder	Equipment Brand	Equipment Model	Model Year	Exhaust Emissions Executive Order Holder	Engine Family	Engine Displacement (cc)	Equipment Description	Nominal Fuel Tank Capacity (L)	Evaporative Emissions Family and Executive Order Number	24-Hour Diurnal FID Result[a,b] (g/day)	Ethanol Results (g/day)	E10 FID Total 24-Hour Diurnal Emission Rate[c] (g/day)	24-hour Diurnal Performance Standard (g/day)	Evaporative Family Emission Limit Differential (g/day)	Evaporative Model Emission Limit (g/day)	Certification Level (g/day)	Certification Option	Emission Control systems: Venting Control Type	Emission Control systems: Tank Barrier Type	Emission Control systems: Exhaust	Fuel Hose Manufacturer	Fuel Hose Permeation Standard ($g ROG/m^2/day$): Standard	Fuel Hose Permeation Standard ($g ROG/m^2/day$): Fuel Hose Certification Level or EO	Fuel Tank Manufacturer	Fuel Tank Permeation Standard ($g ROG/m^2/day$): Standard	Fuel Tank Permeation Standard ($g ROG/m^2/day$): Certification Level or EO	Carbon Canister Manufacturer	Carbon Canister Butane Working Capacity (g HC/L): Standard	Carbon Canister Butane Working Capacity (g HC/L): Certification Level or EO	Carbon Canister Working Capacity (g)
E10-4	Briggs & Stratton Corporation	Snapper	7800841-01	2012	Briggs & Stratton Corporation	CBSXS.1901VP	190	WB Mower	1.03	CNV2 U-U-002-0712-3	0.768 0.684 0.641	0.275 0.166 0.150	0.829 0.739 0.692	1.000	0.150	0.850	0.59	Performance	Canister	Nylon		Mark IV Automotive	15	7 C-U-06-030							
E10-5	Honda Motor Co., Ltd.	Husqvarna	961330019 03 7021P	2014	Honda Motor Co., Ltd.	EHNXS.1871AA	161	WB Mower	0.91	CCHNXW1A U-U-001-0670	0.806 0.782 0.813	0.149 0.143 0.143	0.870 0.845 0.878	1.000	0.100	0.900	0.79	Performance	Canister	Coextruded			15								
E10-6	Briggs & Stratton Corporation	Ariens	961360014 01 A140B21 - 96136500	2012	Briggs & Stratton Corporation	CBSXS.1401VA	140	WB Mower	0.753	CNV1 U-U-002-0709-1	0.597 0.535 0.525	0.133 0.137 0.134	0.645 0.578 0.567	1.000			0.74	Performance	Canister	Nylon		Avon Automotive	15	9 G-05-018							
E10-19	Honda Motor Co., Ltd.	Honda	HRR2169VKA	2014	Honda Motor Co., Ltd.	EHNSX.1871AA	161	WB Mower	0.91	CCHNXW1A U-U-001-0670	0.652 0.723 0.725	0.122 0.125 0.116	0.704 0.781 0.783	1.000	0.100	0.900	0.79	Performance	Canister	Coextruded			15	3 Q-11-012							
E10-21	The Toro Company	Toro	22297	2014	Kawasaki	DKAXS.1791CC	179	WB Mower	3.76	CNEL4XBF U-U-052-0129	0.495 0.454 0.465	0.168 0.154 0.157	0.535 0.490 0.502	1.000			0.57	Performance	Canister	Nylon		Avon Automotive	15	9 G-05-018							
E10-24	Loncin Motor Co., Ltd.	Toro	20372	2012	Loncin Motor Co., Ltd.	CCGPS.1591PC	159	WB Mower	1	CPCCGPS.159 U-U-145-0064-1	0.632 0.617 0.633	0.109 0.110 0.104	0.683 0.666 0.684	1.000			0.70	Performance	Canister	Treated HDPE		Avon Automotive	15	9 G-05-018							
E10-13	Jiangsu Jiangdong Group Co., Ltd.	McLane/ Briggs & Stratton	101	2012	Jiangsu Jiangdong Group Co., Ltd.	CJDGS.1271UA	127	Lawn Edger	2	CM9 U-U-068-0051	0.691 0.677 0.678	0.153 0.135 0.147	0.746 0.731 0.732	1.062	0.200	0.862	0.70	Performance	Canister	Metal			15								
E10-16	Briggs & Stratton Corporation	Husqvarna	FT900 960830009 00	2014	Briggs & Stratton Corporation	EBSXS.2081HB	208	Tiller	3.07	CMH3 U-U-002-0826	0.587 0.573 0.559	0.537 0.479 0.306	0.634 0.619 0.604	1.122			0.83	Performance	Canister	Metal			15								
E10-22	Jiangsu Jiangdong Group Co., Ltd.	Power Trim	200	2012	Jiangsu Jiangdong Group Co., Ltd.	CJDGS.1271UA	127	Lawn Edger	2	CM9 U-U-068-0051	0.473 0.446 0.424	0.105	0.511 0.482 0.458	1.062	0.200	0.862	0.70	Performance	Canister	Metal			15								
E10-29 14P1	Briggs & Stratton Corporation	Snapper	130G32-0021-F1	2014	Briggs & Stratton Corporation	EBSXS.2081HB	208	Tiller	3.07	CMH3 U-U-002-0826	0.659 0.632 0.660	0.132 0.476 0.303	0.712 0.683 0.713	1.122			0.83	Performance	Canister	Metal		Tsu Tah Elastomerics	15	9 C-U-05-012							
E10-1 13D8	Kubota Corporation	Kubota	T1880	2013	Kohler Company	DKHXS.5972GB	597	Riding Mower	16	CO3 U-U-003-0234	1.792 1.740 1.770	0.530 0.468 0.536	1.935 1.879 1.912	2.096				Design	Canister	Other		Avon Automotive	15	9 G-05-018		1.5	small production volume exemption	Miniature Precision Components, Inc.	1.4	1.8 Q-07-009	28.09
E10-11 13D19	Briggs & Stratton Corporation	Snapper	7800932-00	2013	Briggs & Stratton Corporation	DBSXS.3442VA	344	Riding Mower	7.4	CMG1 U-U-002-0785-1	0.702 1.043 1.108	0.161 0.215 0.176	0.758 1.126 1.197	1.614				Design	Canister	Metal		Avon Automotive	15	9 G-05-018		1.5		Sentec E&E Co., Ltd.	1.4	1.4 C-U-06-031	10.2
E10-25 13D12	Lifan Industry (Group) Co., Ltd.	Lifan	Energy Storm 8000E	2013	Lifan Industry (Group) Co., Ltd.	DCLGS.4202CA	420	Generator	25	CM6 U-U-074-0124-1	1.260 1.200 1.210	0.180 0.336 0.341	1.361 1.296 1.307	2.600				Design	Canister	Metal		Avon Automotive; Wenzhou Depurate Environmental Three-way Catalyst Co., Ltd.; Hangzhou Rewin Vehicle Parts Co., Ltd.; Tsu Tah Elastomerics	15	9 (G-05-018), 4 (Q-08-037), 4 (Q-08-005), 9 (C-U-05-012)		1.5		Sentec E&E Co., Ltd.	1.4	1.6 C-U-07-016	38.8
E10-18	Fuji Heavy Industries, Ltd.	Echo Bear Cat	SC2170	2012	Subaru (Fuji Heavy Industries, Ltd.)	CFJXS.1691GC	169	Chipper	3.2	CM1 U-U-012-0408-2	1.469 1.465 1.694	0.271 0.254 0.283	1.587 1.582 1.830	1.000			0.71	Performance	Canister	Metal			15								
E10-2 13D10	United Power Equipment Co., Ltd.	Generac Centurion by Generac Power Systems, Inc.	GP3250	2013	United Power Equipment Co., Ltd.	DUPMS.2081CB	208	Generator	15	CM5 U-U-125-0078	1.404 1.687 1.669	0.216 0.271 0.262	1.516 1.822 1.803	1.790				Design	Canister	Metal	TWC, PAIR	Hangzhou Rewin Vehicle Parts Co., Ltd.	15	4 Q-08-005		1.5		Hangzhou Rewin Vehicle Parts Co., Ltd.	1.4	1.7 C-U-07-009	25.69
E10-12 14D5	Husqvarna Consumer Outdoor Products N.A. Inc.	Husqvarna	YT 42 LS 960430190 00	2014	Kawasaki	EKAXS.6032CC	603	Riding Mower	11.21	CP U-U-006-0483	3.020 3.100 3.140	0.504 0.545 0.627	3.262 3.348 3.391	1.828				Design	Canister	Treated HDPE		Avon Automotive	15	9 G-05-018	The Plastics Group	1.5	2.47 Q-07-019	Miniature Precision Components, Inc.	1.4	2.5 C-U-06-015	28.1
E10-28 13D17	Techtronic Industries North America, Inc.	Gravely (Ariens)	986052 (7500 W)	2013	Honda Motor Co., Ltd.	DHNXS.3892AB	389	Generator	30.3	CM8HCP4 U-U-060-0204-1	2.941 2.849 2.932	0.352 0.669 0.390	3.176 3.077 3.167	2.897				Design	Canister	Metal		Parker Hannifin Corporation	15	6 C-U-06-010		1.5		Sentec E&E Co., Ltd.	1.4	2.1 C-U-07-011	64.5

[a] FID = flame ionization detector

[b] 24-Hour diurnal FID results include a contribution from ethanol. A factor will be developed to correct for the contribution from ethanol.

[c] Using default correction factor of 1.08 to correct for ethanol.

Engine Number	Evaporative Emissions Executive Order Holder	Equipment Brand	Equipment Model	Model Year	Engine Manufacturer	Engine Family	Engine Displacement (cc)	Equipment Description	Nominal Fuel Tank Capacity (L)	Evaporative Emissions Family and Executive Order Number	24-Hour Diurnal FID Result[a,b] (g/day)	Ethanol Results (g/day)	E10 FID Total 24-Hour Diurnal Emission Rate[c] (g/day)	24-hour Diurnal Performance Standard[d] (g/day)	Evaporative Family Emission Limit Differential (g/day)	Evaporative Model Emission Limit (g/day)	Certification Level (g/day)	Certification Option	Emission Control systems: Venting Control Type	Emission Control systems: Tank Barrier Type	Emission Control systems: Exhaust	Fuel Hose Manufacturer	Fuel Hose Permeation Standard ($g ROG/m^2/day$): Standard	Fuel Hose Permeation Standard ($g ROG/m^2/day$): Fuel Hose Certification Level or EO	Fuel Tank Manufacturer	Fuel Tank Permeation Standard ($g ROG/m^2/day$): Standard	Fuel Tank Permeation Standard ($g ROG/m^2/day$): Certification Level or EO	Carbon Canister Manufacturer	Carbon Canister Butane Working Capacity (g HC/L): Standard	Carbon Canister Butane Working Capacity (g HC/L): Certification Level or EO	Carbon Canister Working Capacity (g)
E10-3	Honda Motor Co., Ltd.	Honda	HHT35SUKAT	2013	Honda Motor Co., Ltd.	DHNXS.0364AA	36	Line Trimmer	0.63	DHNXS.0364AA U-U-001-0596	0.467 0.483 0.520	0.183 0.198 0.192	0.504 0.522 0.562	0.985				≤ 80 cc		Coextruded						2.0					
E10-7	MTD Southwest Inc.	Craftsman	316.794011	2013	MTD Southwest, Inc.	DMTDS.0324PB	32	BP Blower	0.650	DMTDS.0324PB U-U-020-0229	0.475 0.425 0.459	0.162 0.135 0.149	0.513 0.459 0.496	0.986				≤ 80 cc		Treated HDPE		Avon Automotive		13 Q-08-021	Custom Pak, Inc.	2.0	0.35 C-U-07-005				
E10-8	MTD Southwest Inc.	Craftsman	316.794610	2014	MTD Southwest, Inc.	EMTDS.0254MR	25	Blower	0.410	EMTDS.0254MR U-U-020-0244	0.562 0.655 0.639	0.179 0.234 0.214	0.607 0.707 0.690	0.973				≤ 80 cc		Treated HDPE		Avon Automotive		13 Q-08-021	Custom Pak, Inc.	2.0	0.35 C-U-07-005				
E10-9	MTD Southwest Inc.	Craftsman	316.731971	2014	MTD Southwest, Inc.	EMTDS.0324GL	30	Trimmer	0.355	EMTDS.0324GL U-U-020-0254	0.505 0.614 0.575	0.112 0.191 0.198	0.545 0.663 0.621	0.970				≤ 80 cc				Avon Automotive		13 Q-08-021	Custom Pak, Inc.	2.0	0.35 C-U-07-005				
E10-10	MTD Southwest Inc.	Craftsman	316.73193.1	2014	MTD Southwest, Inc.	EMTDS.0324KS	32	Trimmer	0.355	EMTDS.0324KS U-U-020-0255	0.654 0.687 0.819	0.232 0.251 0.287	0.706 0.742 0.885	0.970				≤ 80 cc		Treated HDPE		Avon Automotive		13 Q-08-021	Custom Pak, Inc.	2.0	0.35 C-U-07-005				

[a] FID = flame ionization detector

[b] 24-Hour diurnal FID results include a contribution from ethanol. A factor will be developed to correct for the contribution from ethanol.

[c] Using default correction factor of 1.08 to correct for ethanol.

[d] There are no diurnal emission standards for engines ≤ 80 cc. The calculated standards for these engines are the standards that would apply for 81 - 224 cc engines with the same fuel tank nominal capacity.

Attachment 1

TP-902 *Test Procedure for Determining Diurnal Evaporative Emissions from Small Off-Road Engines and Equipment*

California Environmental Protection Agency

Air Resources Board

Small Off-Road Engine and Equipment Evaporative Emissions Test Procedure

TP - 902

Test Procedure for Determining Diurnal Evaporative Emissions from Small Off-Road Engines and Equipment

Adopted: July 26, 2004

TP-902
TABLE OF CONTENTS

LIST OF TABLES AND FIGURES

California Environmental Protection Agency
Air Resources Board

Small Off-Road Engine and Equipment Evaporative Emissions Test Procedure

TP-902

Test Procedure for Determining Diurnal Evaporative Emissions from Small Off-Road Engines and Equipment

A set of definitions common to all Certification and Test Procedures are in Title 13, California Code of Regulations (CCR), Section 2752 et seq.

For the purpose of this procedure, the term "CARB" refers to the California Air Resources Board, and the term "Executive Officer" refers to the CARB Executive Officer or his or her authorized representative or designate.

1. APPLICABILITY

This Test Procedure, TP-902, is used by the Air Resources Board to determine the diurnal and resting loss evaporative emissions from small off-road engines and equipment less than or equal to 19 kilowatts. Small off-road engines are defined in Title 13, California Code of Regulations (CCR), section 2401 et seq. This Test Procedure is proposed pursuant to Section 43824 of the California Health and Safety Code (CH&SC) and is applicable in all cases where small off-road engines are sold, supplied, offered for sale, or manufactured for use in the State of California.

1.1 Requirement to Comply with All Other Applicable Codes and Regulations

Certification or approval of any engine or evaporative emission control system by the Executive Officer does not exempt the engine or evaporative emission control system from compliance with other applicable codes and regulations such as state and federal safety codes and regulations.

1.2 Safety

This test procedure involves the use of flammable materials and operations and should only be used by or under the supervision of those familiar and experienced in the use of such materials and operations. Appropriate safety precautions should be observed at all times while performing this test procedure.

2. PERFORMANCE STANDARDS

The minimum performance standards for certification of evaporative emission control systems on small off-road engines or equipment that use small off-road engines is defined in CCR Title 13, Chapter 15, Article 1, Section 2754.

3. PRE-CERTIFICATION REQUIREMENTS

3.1 Durability

A demonstration of durability of the applicant's evaporative emission control system is required prior to performing an evaporative emissions test.

Prior to the commencement of a durability demonstration, the applicant is required to submit and obtain approval of an evaporative emission durability test procedure. Once approved, a manufacturer is not required to obtain a new approval for an evaporative emission durability demonstration unless changes result in new testing requirements.

Tanks that have a secondary operation for drilling holes for insertion of fuel line and grommet system may have these eliminated for purposes of durability demonstration.

Components shall be deemed acceptable if they remain functional after the durability demonstration prescribed below. Fuel tanks utilized for certification must have pressure/vacuum (if applicable) and slosh testing prior to certification testing.

The Executive Officer shall review the method based on the following requirements:

(a) The durability test must actuate control valves, cables, and linkages, where applicable, for a minimum of 5000 cycles.

(b) The Pressure/Vacuum test is performed prior to any preconditioning of the fuel tank. Determine the fuel tank system's design pressure and vacuum limits under normal operating conditions considering the influence of any associated pressure/vacuum relief components. Pressurize the empty tank, sealed with the OEM fuel cap, or a modified OEM fuel cap as required, to within 10% of the system's normal high pressure operating limit and then evacuate to within 10% of the system's normal vacuum operating limit. If the fuel tank has no features that would cause positive or negative pressures during normal operation, then pressure/vacuum cycling is not required. The tank pressure/vacuum cycling shall be performed in a 49º C+/- 3º C ambient with compressed air of no less than 21º C. Repeat the pressure/vacuum process until the tank has been subjected to not less than 1000 cycles in 8 hours +/- 1 hour.

(c) The durability test must include a slosh test of the engines fuel tank. The slosh test can be performed during the preconditioning period. A slosh test must be performed on a fuel tank filled to 50 percent capacity with CERT fuel. The fuel tank must be sealed with the OEM fuel cap. A laboratory orbital shaker table or similar device is then used to subject the tank to a peak horizontal centripetal acceleration of at least 2.4 meter/second^2 at a frequency of 2 cycles per second +/- 0.25 for one million cycles. As an alternative, slosh testing may be performed using the method specified in 40 CFR Part 1051 §1051.515 (c).

(d) For systems that utilize a carbon canister, the durability test procedure(s) shall include thermal cycling and vibration exposure of the canister.

   (1) For thermal cycling, the test must subject the canister to 100 cycles of the following temperature profile:

      (A) Heat and hold at 60ºC ± 2ºC for 30 minutes. (Up to 10 minutes is allowed for the temperature to rise and stabilize.)

(B) Cool and hold at 0ºC ± 2ºC for 30 minutes. (Up to 20 minutes is allowed for the temperature to reach 0ºC during the cooling period.)

(2) For vibration exposure, at a minimum, the canister must be placed in a suitable test fixture while maintaining its specified orientation (as designed). Subject the fixture to a peak horizontal vibration force of 4.5G x 60Hz x 10^7 times.

3.2 Canister Working Capacity

(a) For evaporative emission control systems that only use a carbon canister and do not pressurize the fuel tank, the carbon canister must have a working capacity of at least 1.4 grams of vapor storage capacity per liter of nominal fuel tank volume for tanks greater than or equal to 3.78 liters, and 1.0 grams of vapor storage capacity per liter of nominal fuel tank volume for tanks less than 3.78 liters. For evaporative emission control systems that use a carbon canister and pressurized fuel tank, the working capacity must be specified by the applicant. For all systems utilizing actively purged carbon canisters, running loss emissions must be controlled from being emitted into the atmosphere.

(b) Working capacity is determined following the procedure in Attachment 1 of this test procedure. In lieu of the loading and purge rates specified in Attachment 1, the canister manufacturer's maximum loading and purge rates may be used.

3.3 Engine Purge

If a canister is used, the engine must actively purge the canister when the engine is running. This requirement may not apply to Small Production Volume Tanks specified in 13 CCR 2766.

4. GENERAL SUMMARY OF TEST PROCEDURE

A Sealed Housing for Evaporative Determination (SHED) is used to measure diurnal emissions. This method subjects test engines to a preprogrammed temperature profile while maintaining a constant pressure and continuously sampling for hydrocarbons with a Flame Ionization Detector (FID). The volume of a SHED enclosure can be accurately determined. The mass of total hydrocarbons that emanates from a test engine over the test period is calculated using the ideal gas equation.

This test procedure measures diurnal emissions from engines or equipment with complete evaporative emission control systems as defined in 13 CCR 2752 (a)(8) by subjecting them to a hot soak and diurnal test sequence. The engine with complete evaporative emission control system can be tested without the equipment chassis. The basic process is as follows:

- Fill the engine fuel tank with fuel and operate at maximum governed speed for 5-minutes
- Precondition the evaporative emission control and fuel delivery system
- Drain and fill fuel tank to 50% capacity with California certification fuel
- Purge carbon canister (if so equipped) with 400 bed volumes of nitrogen or dry air at the canister manufacturer's recommended rate
- Operate engine at the maximum governed speed for fifteen minutes
- Subject engine/equipment to a one-hour constant 95°F hot soak
- Soak engine/equipment for two hours at 65°F

- Subject engine/equipment to a 24-hour variable (65°F - 105°F - 65°F) temperature diurnal profile

The mass of total hydrocarbons measured by the SHED over the 24-hour diurnal profile is compared with the performance standards in CCR Title 13, Chapter 15, Article 1, Section 2754. Engines or equipment that meet the appropriate performance standard shall be considered compliant.

5. INSTRUMENTATION

The instrumentation necessary to perform evaporative emission testing for small off-road engines is the same instrumentation used for passenger cars and light duty vehicles, and is described in 40 CFR 86.107-96. The ARB will consider data generated with mini-SHEDs as valid if approved as an alternative test procedure.

5.1 Diurnal Evaporative Emission Measurement Enclosure

References to methanol in this test procedure can be disregarded.

The diurnal evaporative emissions measurement enclosure shall be equipped with an internal blower or blowers coupled with an air temperature management system (typically air to water heat exchangers and associated programmable temperature controls) to provide for air mixing and temperature control. The blower(s) shall provide a nominal total flow rate of 0.8 ± 0.2 ft^3/min per ft^3 of the nominal enclosure volume, V_n. The inlets and outlets of the air circulation blower(s) shall be configured to provide a well-dispersed air circulation pattern that produces effective internal mixing and avoids significant temperature or hydrocarbon and alcohol stratification. The discharge and intake air diffusers in the enclosure shall be configured and adjusted to eliminate localized high air velocities which could produce non-representative heat transfer rates between the engine fuel tank(s) and the air in the enclosure. The air circulation blower(s), plus any additional blowers if required, shall maintain a homogeneous mixture of air within the enclosure.

The enclosure temperature shall be taken with thermocouples located 3 feet above the floor at the approximate mid-length of each side wall of the enclosure and within 3 to 12 inches of each side wall. The temperature conditioning system shall be capable of controlling the internal enclosure air temperature to follow the prescribed temperature versus time cycle as specified in 40 CFR §86.133-90 as modified by paragraph III.D.10 (diurnal breathing loss test) of the “California Evaporative Emission Standards and Test Procedures for 2001 and Subsequent Model Motor Vehicles” within an instantaneous tolerance of ± 3.0^{o}F and an average tolerance of ± 2.0^{o}F as measured by side wall thermocouples. The control system shall be tuned to provide a smooth temperature pattern, which has a minimum of overshoot, hunting, and instability about the desired long-term temperature profile.

The enclosure shall be of sufficient size to contain the test equipment with personnel access space. It shall use materials on its interior surfaces, which do not adsorb or desorb hydrocarbons, or alcohols (if the enclosure is used for alcohol-fueled vehicles). The enclosure shall be insulated to enable the test temperature profile to be achieved with a heating/cooling system, which has minimum surface temperatures in the enclosure no less than 25.0^{o}F below the minimum diurnal temperature specification. The enclosure shall be equipped with a pressure transducer with an accuracy and precision of ± 0.1 inches H_2O. The enclosure shall be constructed with a minimum number of seams and joints, which provide potential leakage paths. Particular attention shall be given to sealing and gasketing of such seams and joints to prevent leakage.

The enclosure shall be equipped with features, which provide for the effective enclosure volume to expand and contract in response to both the temperature changes of the air mass in the enclosure, and any fluctuations in the ambient barometric pressure during the duration of the test. Either a variable volume enclosure or a fixed volume enclosure may be used for diurnal emission testing.

A variable volume enclosure shall have the capability of latching or otherwise constraining the enclosed volume to a known, fixed value, V_n. The V_n shall be determined by measuring all pertinent dimensions of the enclosure in its latched configuration, including internal fixtures, based on a temperature of 84^{o}F, to an accuracy of ± 1/8 inch (0.5 cm) and calculating the net V_n to the nearest 1 ft^3. In addition, V_n shall be measured based on a temperature of 65^{o}F and 105^{o}F. The latching system shall provide a fixed volume with an accuracy and repeatability of $0.005xV_n$. Two potential means of providing the volume accommodation capabilities are; a moveable ceiling which is joined to the enclosure walls with a flexure, or a flexible bag or bags of Tedlar or other suitable materials, which are installed in the enclosure and provided with flowpaths which communicate with the ambient air outside the enclosure. By moving air into and out of the bag(s), the contained volume can be adjusted dynamically. The total enclosure volume accommodation shall be sufficient to balance the volume changes produced by the difference between the extreme enclosure temperatures and the ambient laboratory temperature with the addition of a superimposed barometric pressure change of 0.8 in. Hg. A minimum total volume accommodation range of $\pm 0.07xV_n$ shall be used. The action of the enclosure volume accommodation system shall limit the differential between the enclosure internal pressure and the external ambient barometric pressure to a maximum value of ± 2.0 inches H_2O.

The fixed volume enclosure shall be constructed with rigid panels that maintain a fixed enclosure volume, which shall be referred to as V_n. V_n shall be determined by measuring all pertinent dimensions of the enclosure including internal fixtures to an accuracy of ± 1/8 inch (0.5 cm) and calculating the net V_n to the nearest 1 ft^3. The enclosure shall be equipped with an outlet flow stream that withdraws air at a low, constant rate and provides makeup air as needed, or by reversing the flow of air into and out of the enclosure in response to rising or falling temperatures. If inlet air is added continuously throughout the test, it must be filtered with activated carbon to provide a relatively constant hydrocarbon and alcohol level. Any method of volume accommodation shall maintain the differential between the enclosure internal pressure and the barometric pressure to a maximum value of ±2.0 inches of water. The equipment shall be capable of measuring the mass of hydrocarbon, and alcohol (if the enclosure is used for alcohol-fueled equipment) in the inlet and outlet flow streams with a resolution of 0.01 gram. A bag sampling system may be used to collect a proportional sample of the air withdrawn from and admitted to the enclosure. Alternatively, the inlet and outlet flow streams may be continuously analyzed using an on-line Flame Ionization Detector (FID) analyzer and integrated with the flow measurements to provide a continuous record of the mass hydrocarbon and alcohol removal.

An online computer system or strip chart recorder shall be used to record the following parameters during the diurnal evaporative emissions test sequence:

- Enclosure internal air temperature
- Diurnal ambient air temperature specified profile as defined in 40 CFR §86.133-90 as modified in paragraph III.D.10 of the “California Evaporative Emission Standards and Test Procedures for 2001 and Subsequent Model Motor Vehicles” (diurnal breathing loss test).
- Enclosure internal pressure
- Enclosure temperature control system surface temperature(s)
- FID output voltage recording the following parameters for each sample analysis:

– zero gas and span gas adjustments
– zero gas reading
– enclosure sample reading
– zero gas and span gas readings

The data recording system shall have a time resolution of 30 seconds and shall provide a permanent record in magnetic, electronic or paper media of the above parameters for the duration of the test.

Other equipment configurations may be used if approved in advance by the Executive Officer. The Executive Officer shall approve alternative equipment configurations if the manufacturer demonstrates that the equipment will yield test results equivalent to those resulting from use of the specified equipment.

5.2 Calibrations

Evaporative emission enclosure calibrations are specified in 40 CFR §86.117-90. Methanol measurements may be omitted when methanol-fueled engines will not be tested in the evaporative enclosure. Amend 40 CFR §86.117-90 to include an additional subsection 1.1, to read:

The diurnal evaporative emission measurement enclosure calibration consists of the following parts: initial and periodic determination of enclosure background emissions, initial determination of enclosure volume, and periodic hydrocarbon (HC) and methanol retention check and calibration. Calibration for HC and methanol may be conducted in the same test run or in sequential test runs.

5.2.1 The initial and periodic determination of enclosure background emissions shall be conducted according to the procedures specified in §86.117-90(a)(1) through (a)(6). The enclosure shall be maintained at a nominal temperature of 105.0°F throughout the four-hour period. Variable volume enclosures may be operated either in the latched volume configuration, or with the variable volume feature active. Fixed volume enclosures shall be operated with inlet and outlet flow streams closed. The allowable enclosure background emissions of HC and/or methanol as calculated according to 40 CFR §86.117-90(a)(7) shall not be greater than 0.05 grams in 4 hours. The enclosure may be sealed and the mixing fan operated for a period of up to 12 hours before the initial HC concentration reading (C_{HCi}) and the initial methanol concentration reading (C_{CH3OHi}) is taken and the four-hour background measurement period begins.

5.2.2 The initial determination of enclosure internal volume shall be performed according to the procedures specified in paragraph I.A.1.3 of the "California Evaporative Emission Standards and Test Procedures for 2001 and Subsequent Model Motor Vehicles." If the enclosure will be used for hot soak determination, the determination of enclosure internal volume shall also be performed based on 105°F.

5.2.3 The HC and methanol measurement and retention checks shall evaluate the accuracy of enclosure HC and methanol mass measurements and the ability of the enclosure to retain trapped HC and methanol. The check shall be conducted over a 24-hour period with all of the normally functioning subsystems of the enclosure active. A known mass of propane and/or methanol shall be injected into the enclosure and an initial enclosure mass measurement(s) shall be made. The enclosure shall be subjected to the temperature cycling specified in paragraph III.D.10.1.7 of the "California Evaporative Emission Standards and Test Procedures for 2001 and Subsequent Model Motor Vehicles" (revising 40 CFR §86.133-90(l)) for a 24-hour period. The temperature cycle shall begin at 105EF (hour 11) and continue according to the schedule until a full 24-hour cycle is completed. A final enclosure mass measurement(s) shall be made. The following procedure shall be performed prior to the introduction of the enclosure into service and following any modifications or repairs to the enclosure that may impact the integrity of this enclosure; otherwise, the following procedure shall be performed on a monthly basis. (If six consecutive monthly retention checks are successfully completed without corrective action, the following procedure may be determined quarterly thereafter as long as no corrective action is required.)

(A) Zero and span the HC analyzer.

(B) Purge the enclosure with atmospheric air until a stable enclosure HC level is attained.

(C) Turn on the enclosure air mixing and temperature control system and adjust it for an initial temperature of 105.0°F and a programmed temperature profile covering one diurnal cycle over a 24 hour period according to the profile specified in paragraph III.D.10.1.7. Of the "California Evaporative Emission Standards and Test Procedures for 2001 and Subsequent Model Motor Vehicles" (revising 40 CFR §86.133-90). Close the enclosure door. On variable volume enclosures, latch the enclosure to the enclosure volume measured at 105°F. On fixed volume enclosures, close the outlet and inlet flow streams.

(D) When the enclosure temperature stabilizes at 105.0°F ± 3.0°F seal the enclosure; measure the enclosure background HC concentration (C_{HCe1}) and/or background methanol concentration (C_{CH3OH1}) and the temperature (T_1), and pressure (P_1) in the enclosure.

(E) Inject into the enclosure a known quantity of propane between 2 to 6 grams and a known quantity of methanol in gaseous form between 2 to 6 grams. For evaporative emission enclosures that will be used for testing equipment subject to the standards shown in Table 2-1, use a known amount of propane or gaseous methanol between 0.5 to 1.0 grams. The injection method shall use a critical flow orifice to meter the propane and/or methanol at a measured temperature and pressure for a measured time period. Techniques that provide an accuracy and precision of ± 0.5 percent of the injected mass are also acceptable. Allow the enclosure internal HC and/or methanol concentration to mix and stabilize for up to 300 seconds. Measure the enclosure HC concentration (C_{HCe2}) and/or the enclosure methanol concentration (C_{CH3OH2}). For fixed volume enclosures, measure the temperature (T_2) and pressure in the enclosure (P_2). On variable volume enclosures, unlatch the enclosure. On fixed volume enclosures, open the outlet and inlet flow streams. Start the temperature cycling function of the enclosure air mixing and temperature control system. These steps shall be completed within 900 seconds of sealing the enclosure.

(F) For fixed volume enclosures, calculate the initial recovered HC mass (M_{HCe1}) according to the following formula:

$$M_{HCe1} = (3.05 \times V \times 10^{-4} \times [P_2 (C_{HCe2} - rC_{CH3OH2})/T_2 - P_1 (C_{HCe1} - rC_{CH3OH1})/T_1])$$

Where:

V is the enclosure volume at 105°F (ft^3)
P_1 is the enclosure initial pressure (inches Hg absolute)
P_2 is the enclosure final pressure (inches Hg absolute)
C_{HCen} is the enclosure HC concentration at event n (ppm C)

C_{CH3OHn} is the enclosure methanol concentration calculated according to 40 CFR §86.117-90 (d)(2)(iii) at event n (ppm C)
r is the FID response factor to methanol
T_1 is the enclosure initial temperature (°R)
T_2 is the enclosure final temperature (°R)

For variable volume enclosures, calculate the initial recovered HC mass and initial recovered methanol mass according to the equations used above except that P_2 and T_2 shall equal P_1 and T_1.

Calculate the initial recovered methanol mass (M_{CH3OH1}) according to 40 CFR §86.117-96(d)(1), as amended March 24, 1993.

If the recovered HC mass agrees with the injected mass within 2.0 percent and/or the recovered methanol mass agrees with the injected mass within 6.0 percent, continue the test for the 24 hour temperature cycling period. If the recovered mass differs from the injected mass by greater than the acceptable percentage(s) for HC and/or methanol, repeat the enclosure concentration measurement in step (E) and recalculate the initial recovered HC mass (M_{HCe1}) and/or methanol mass (M_{CH3OH1}). If the recovered mass based on the latest concentration measurement agrees within the acceptable percentage(s) of the injected mass, continue the test for the 24-hour temperature cycling period and substitute this second enclosure concentration measurement for C_{HCe2} and/or C_{CH3OH2} in all subsequent calculations. In order to be a valid calibration, the final measurement of C_{HCe2} and C_{CH3OH2} shall be completed within the 900-second time limit outlined above. If the discrepancy persists, the test shall be terminated and the cause of the difference determined, followed by the correction of the problems(s) and the restart of the test.

(G) At the completion of the 24-hour temperature cycling period, measure the final enclosure HC concentration (C_{HCe3}) and/or the final enclosure methanol concentration (C_{CH3OH3}). For fixed-volume enclosures, measure the final pressure (P_3) and final temperature (T_3) in the enclosure.

For fixed volume enclosures, calculate the final recovered HC mass (M_{HCe2}) as follows:

$$M_{HCe2} = [3.05 \text{ x } V \text{ x } 10^{-4} \text{ x}(P_3 (C_{HCe3} - rC_{CH3OH3})/T_3 - P_1 (C_{HCe1} - rC_{CH3OH1})/T_1)] + M_{HC,out} - M_{HC, in}$$

Where:

V is the enclosure volume at 105°F (ft^3)
P_1 is the enclosure initial pressure (inches Hg absolute)
P_3 is the enclosure final pressure (inches Hg absolute)
C_{HCe3} is the enclosure HC concentration at the end of the 24-hour temperature cycling period (ppm C)
C_{CH3OH3} is the enclosure methanol concentration at the end of the 24-hour temperature cycling period, calculated according to 40 CFR §86.117-90

(d)(2)(iii) (ppm C)
r is the FID response factor to methanol
T_1 is the enclosure initial temperature (^oR)
T_3 is the enclosure final temperature (^oR)
$M_{HC,out}$ is mass of HC exiting the enclosure, (grams)
$M_{HC,in}$ is mass of HC entering the enclosure, (grams)

For variable volume enclosures, calculate the final recovered HC mass and final recovered methanol mass according to the equations used above except that P_3 and T_3 shall equal P_1 and T_1, and $M_{HC, out}$ and $M_{HC, in}$ shall equal zero.

Calculate the final recovered methanol mass (M_{CH3OH2}) according to 40 CFR §86.117-96(d)(1), as amended March 24, 1993.

(H) If the calculated final recovered HC mass for the enclosures is not within 3 percent of the initial enclosure mass, or if the calculated final recovered methanol mass for the enclosures is not within 6 percent of the initial enclosure mass, then action shall be required to correct the error to the acceptable level.

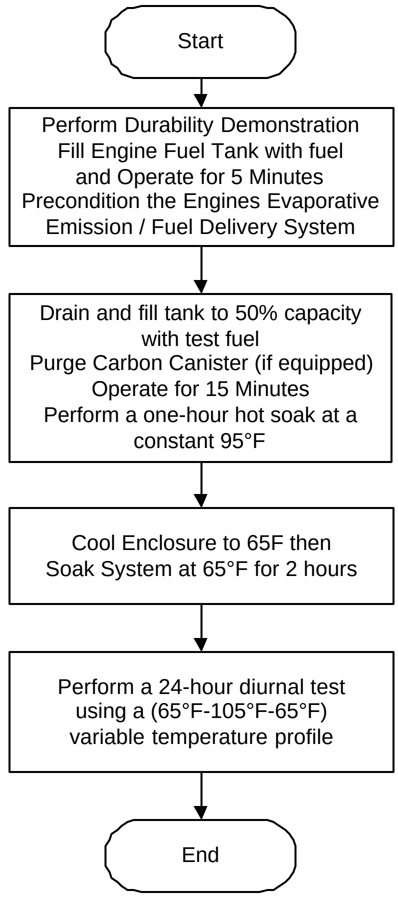
6. TEST PROCEDURE

The test sequence is shown graphically in Figure 1. Methanol measurements may be omitted when methanol-fueled equipment will not be tested in the evaporative enclosure. The temperatures monitored during testing shall be representative of those experienced by the equipment. The equipment shall be approximately level during all phases of the test sequence to prevent abnormal fuel distribution. The temperature tolerance of a soak period may be waived for up to 10 minutes to allow purging of the enclosure or transporting the equipment into the enclosure.

Testing a representative piece of equipment for each evaporative family and comparing the results to the appropriate performance standard determines compliance with requirements of CCR Title 13, Chapter 15, Article 1, Section 2754.

The 24-hour diurnal test sequence is shown in Figure 1.

Figure 1.



6.1 Fuel Tank / Fuel System Preconditioning

The purpose of the preconditioning period is to introduce gasoline into the fuel system and precondition all fuel system components. Precondition the tank and other fuel delivery system components by filling the tank to its nominal capacity with fresh test fuel as specified in Section 7 of these procedures. After filling the tank start the engine and allow it to run at rated speed (unloaded or blade load) for approximately five minutes. Soak the tank and other components at 30º C ± 10º C for not less than 140 days. Data documenting that the tank has reached equilibrium must be provided for tanks soaked less than 140 days. The period of slosh testing may be considered part of the preconditioning period provided each tank and all fuel system components tested remain filled with fuel and are never empty for more than one hour over the entire preconditioning period.

As an alternative, accelerated preconditioning of the tank and components can be accomplished by soaking both at an elevated temperature. Precondition the tank and other fuel delivery system components by filling the tank to its nominal capacity with fresh test fuel as specified in Section 7 of these procedures. After filling the tank start the engine and allow it to run at maximum governed speed (unloaded or blade load) for approximately five minutes. Begin soaking the tank and other components at 40º C ± 2º C. For engines with fuel tanks that have a nominal wall thickness of not greater than 0.15”, soak the tank and all fuel system components for not less than 30 days. For engines with fuel tanks that have a nominal wall thickness of greater than 0.15” but less than or equal to 0.2”, soak the tank and all fuel system components for not less than 60 days. For engines with fuel tanks that have a nominal wall thickness of greater than 0.2” data documenting that the tank and components have reached equilibrium must be provided for tanks soaked less than 140 days.

6.2 Refueling and Hot Soak

Following the preconditioning period, drain the fuel tank and refill to 50 percent of its nominal capacity with test fuel. For evaporative emission control systems that use a carbon canister, the canister must be purged following the preconditioning period but prior to initiating the hot soak test. Purging consists of drawing 400 bed volumes of nitrogen or dry air through the canister at the canister manufacturer’s recommended purge rate. Operate the engine at its maximum governed speed for fifteen minutes. Immediately place the engine in the SHED enclosure preheated to 95°F. Perform a one-hour hot soak at a constant 95°F.

6.3 Forced Cooling

After the hot soak test, purge the enclosure to reduce the hydrocarbon concentration to background levels. Cool the enclosure to attain a wall temperature of 65°F. After cooling the enclosure to 65°F, soak the engine in the enclosure for two hours at 65°F.

6.4 24-Hour Diurnal Test

Immediately after soaking for two hours at 65°F, purge the enclosure to reduce the hydrocarbon concentration to background levels and perform a 24-hour diurnal test using the temperature profile shown in Table 6-1.

Table 6-1.
Diurnal Temperature Profile

Hour	0	1	2	3	4	5	6	7	8	9	10	11	12
(°F)	65.0	66.6	72.6	80.3	86.1	90.6	94.6	98.1	101.2	103.4	104.9	105.0	104.2
Hour	13	14	15	16	17	18	19	20	21	22	23	24	--
(°F)	101.1	95.3	88.8	84.4	80.8	77.8	75.3	72.0	70.0	68.2	66.5	65.0	--

6.5 Calculation of Mass of Diurnal Evaporative Emissions

The calculation of the mass of the diurnal evaporative emissions is as specified in Part III of the “California Evaporative Emission Standards and Test Procedures for 2001 and Subsequent Model Motor Vehicles.”

7. TEST FUEL

Evaporative emission test fuel is specified in Part II Section 100.3 of the "California Exhaust Emission Standards and Test Procedures for 2001 and Subsequent Model Passenger Cars, Light-Duty Trucks and Medium-Duty Vehicles."

8. ALTERNATIVE TEST PROCEDURES

Test procedures, other than specified above, such as the use of a mini-SHED to measure diurnal evaporative emissions, shall only be used if prior written approval is obtained from the ARB Executive Officer. In order to secure the ARB Executive Officer's approval of an alternative test procedure, the applicant is responsible for demonstrating to the ARB Executive Officer's satisfaction that the alternative test procedure is equivalent to this test procedure.

(1) Documentation of any such approvals, demonstrations, and approvals shall be maintained by the ARB Executive Officer and shall be made available upon request.

(2) Once approved for use, an alternative test procedure may be used and referenced by any manufacturer subject to the limitations and constraints in the Executive Order approving the alternative test procedure.

9. REFERENCES

1. California Evaporative Emission Standards and Test Procedures for 2001 and Subsequent Model Passenger Cars, Light-Duty Trucks, and Medium-Duty Vehicles, California Environmental Protection Agency, Air Resources Board, El Monte, CA, 2000.

2. California Exhaust Emission Standards and Test Procedures for 2001 and Subsequent Model Passenger Cars, Light-Duty Trucks and Medium-Duty Vehicles, California Environmental Protection Agency, Air Resources Board, El Monte, CA, 2002.

3. 40 CFR Part 86

Attachment 1 to TP-902

Procedure for
Determining Carbon Canister Performance:
Working Capacity

Attachment 1
TABLE OF CONTENTS

LIST OF FIGURES

Small Off-Road Engine Evaporative Emissions Test Procedure

Attachment 1

Procedure for Determining Carbon Canister Performance: Durability Demonstration and Working Capacity

A set of definitions common to all Certification and Test Procedures are in Title 13, California Code of Regulations (CCR), Section 2752 et seq.
For the purpose of this procedure, the term "CARB" refers to the California Air Resources Board, and the term "Executive Officer" refers to the CARB Executive Officer, or his or her authorized representative or designate.

1 APPLICABILITY

This Test Procedure is used by the Air Resources Board to determine the performance of carbon canisters used to control evaporative emission from equipment that use gasoline powered small off-road engines. Small off-road engines are defined in Title 13, California Code of Regulations (CCR), section 2401 et seq. This Test Procedure is proposed pursuant to Section 43824 of the California Health and Safety Code (CH&SC) and applies to engine or equipment manufacturers seeking an Executive Order for a evaporative control system utilizing a carbon canister.

1.1 Requirement to Comply with All Other Applicable Codes and Regulations

Approval of an evaporative emission control component, technology, or system by the Executive Officer does not exempt the same from compliance with other applicable codes and regulations such as state and federal safety codes and regulations.

1.2 Safety

This test procedure involves the use of flammable liquids and operations and should only be used by or under the supervision of those familiar and experienced in the use of such materials and operations. Appropriate safety precautions should be observed at all times while performing this test procedure.

2 PRINCIPLE AND SUMMARY OF TEST PROCEDURE

These test procedures are designed to provide consistent methods to evaluate the durability and working capacity of carbon canisters utilized on small engine powered equipment.

Working capacity is a defining parameter expressing the mass of hydrocarbons that can be stored in the canister under controlled conditions. The canister’s working capacity is established by repeated canister loading and purging. This procedure involves a cycle that includes a 400 bed volume purge, a 5 minute pause, and then loading the canister with butane mixed 50/50 by volume with air or nitrogen to a measured breakthrough.

3 BIASES AND INTERFERENCES

To accurately quantify the working capacity the complete test system must be leak tight. Loose fittings and connectors may result in leaks that can significantly affect working capacity determinations.

Care should be taken to minimize or limit the humidity of the air or nitrogen used to purge the canister. Humid purge air can bias canister desorption weight measurements. Dryerite ($CaCl_2$), or other suitable dehumidification methods, must be used to control the humidity of the purge air.

4 SENSITIVITY AND RANGE

The minimum sensitivity of the balance must be selected using good engineering judgment.

5 EQUIPMENT CALIBRATIONS

Mass flow meters must undergo an annual multiple point calibration with a primary standard and have a R^2 coefficient of 0.99 or greater.

The top loading balance must be calibrated with ASTM Class I weights prior to use per the manufacturer specifications. Prior to use the balance must be challenged with weights above and below the range of mass measurements.

6 CARBON CANISTER WORKING CAPACITY DETERMINATION

6.1 Number of Test Cycles

Working capacity is determined through cyclic loading and purging of a carbon canister. Ten or more cycles may be required to stabilize new carbon. A minimum of three cycles is adequate if the carbon has a previous history of stabilization with butane or gasoline vapors. The “working capacity” value is the average of the butane mass supplied to the canister for last two repeatable cycles.

6. 2 Canister Purge

The sequence starts by first purging the canister with 400 bed volumes of dry air or nitrogen in 30 minutes at laboratory conditions. Bed volume is the design volume of the carbon contained in the canister. Purge for all the canister models is defined as a 400 bed volume purge in approximately 30 minutes. The purge rate will therefore vary with canister size. Purge may be accomplished by drawing a vacuum at the tank or purge port, or by pushing air or N2 into the atmospheric vent.

6.3 Pause

Pause testing for approximately 5 minutes between both purge and load and also load and purge sequences.

6.4 Measurement

Weigh the test canister before and after each canister load sequence.

6.5 Canister Load

Load the test canister with butane mixed 50/50 by volume with air or nitrogen until the specified breakthrough criteria has been met. The canister load is accomplished by flowing the butane mixture into the canister via the tank fitting. The butane load rates and breakthrough criteria are determined by canister's bed volume. In order to accommodate the expected wide range of canister bed volumes expected in the small engine powered equipment, four ranges of canister loading and breakthrough criteria are defined: small (< 99cc), medium (100 to 249cc) large (249 to 550cc) and extra large (> 550cc). The load and breakthrough criteria are defined as follows:

Carbon Canister Bed Volume	Small < 99cc	Medium 100 to 249cc	Large 249cc to 550	Extra Large >550
Butane Load Rate [grams C_4H_{10} / hour]	5.0	10.0	15.0	15.0
Break-through limit [grams](*)	2.0	2.0	2.0	2.0

(*). If the canister shows weight loss prior to the 2.0 grams breakthrough then an alternate lower breakthough limit can be used.

7 CALCULATING RESULTS

The working capacity is the average test canister weight gain in grams determined from the last two load cycles. The resultant working capacity is expressed in grams of C_4H_{10}

8 QUALITY ASSURANCE / QUALITY CONTROL (QA/QC)

This section is reserved for future specification.

9 RECORDING DATA

Record data on a form similar to the one shown in Figure 1 (see page 7).

10 FIGURES

Figure 1. Canister Data Sheet

Figure 1
Canister Data Sheet

Canister Manufacturer:

Canister I.D:

Tested By:

Canister Volume [cc]:

Canister Purge Data

Time Start/End		Duration [seconds]	Flow Rate Q [LPM]	Initial Weight W_i [grams]	Final Weight W_f [grams]	Weight Loss W_l [grams]

Canister Load Data

Time Start/End		Duration [seconds]	Butane Rate Q_b [g/hr]	Initial Weight W_i [grams]	Final Weight W_f [grams]	Break-Through W_b [grams]	Weight Gain W_g [grams]
Working Capacity [grams C_4H_{10}]							