Organic Gas Speciation Profiles for
Catalyzed Gasoline-Powered Vehicle Stabilized Running Exhaust—E6 Fuel
(OG2303 & OG2304)

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1 Introduction

This memo addresses an update to the current gasoline vehicle stabilized exhaust profiles using proposed profiles OG2303 (Catalyzed gasoline vehicle stabilized exhaust running summer-grade E6 fuel) and OG2304 (Catalyzed gasoline vehicle stabilized exhaust running winter-grade E6 fuel). The new profiles will be used to replace the existing profiles OG2104 through OG2109 (Catalyzed gasoline vehicle stabilized exhaust SSD ethanol 2% oxygen MTBE phase-out) for the related categories for calendar years 2004 to 2009 during which E6 gasoline fuel (i.e. 6%vol ethanol or 2%wt oxygen) was used in California. It should be noted that profiles OG2104 through OG2109 were not obtained from actual source testing data. Rather, they were derived by adjusting the stabilized exhaust profile for MTBE-based fuel (i.e. California Reformulated Gasoline Phase 2) for each specific calendar year (e.g. OG2104 is for year 2004, OG2105 is for year 2005, and so on) [1]. Both the previous and proposed profiles are applied to categories of catalyzed gasoline vehicle stabilized exhaust. The catalyzed gasoline vehicle idle exhaust categories are also mapped to these profiles (see Appendix 1).

The updated stabilized exhaust profiles proposed in this memo, OG2303 (for E6 summer fuel) and OG2304 (for E6 winter fuel), are based on source testing results. In 2005 and 2006, CARB conducted the Seventeenth Light-Duty Gasoline Vehicle Surveillance Program (VSP17) to measure criteria pollutant emissions and speciated TOG emissions for vehicles representative of the California vehicle fleet after the transition to ethanol-containing fuels from MTBE-containing fuels. Under VSP17, a total of forty-two in-use vehicles (see Appendix 2 for vehicle information) were randomly selected for exhaust organic gas speciation tests. Twenty-five of these vehicles (all equipped with catalytic converters) were fueled with summer-grade E6 gasoline; and the other seventeen (sixteen equipped with catalyst converter and one without catalyst coverter) were fueled with winter-grade E6 gasoline.

2 Methodology

In the VSP17 speciation tests, the organic gases from tailpipe exhausts were sampled as the vehicles were running on the unified cycle (UC), which was developed by CARB as a dynamometer driving schedule for light-duty vehicles in 1992 [2, 3]. The UC test cycle has a three-phase (bag) structure and it consists of the following segments (Figure 1):

- Cold start phase (Bag 1): 300 seconds and 1.2 miles
- Stabilized phase (Bag 2): 1135 seconds and 8.6 miles
- Hot soak: 10 minutes

- Hot start phase (Bag 3): a duplicate of Bag 1, 300 seconds and 1.2 miles

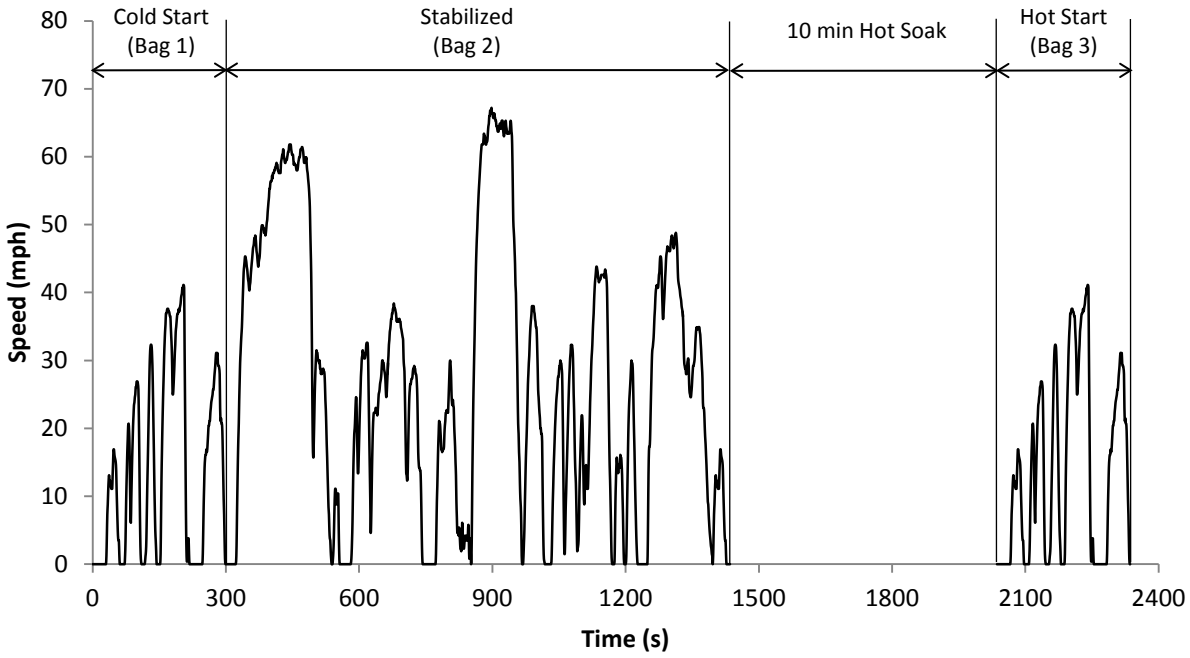

Figure 1. Unified Cycle

Phase 1 (i.e. Bag 1) and Phase 2 (i.e. Bag 2) are run consecutively, followed by a ten minute hot soak, then Phase 3 (i.e. Bag 3) which is a duplicate of Phase 1 (i.e. Bag 1). The emissions from a start generally end after one or two minutes of vehicle operation. Therefore, the samples collected in Bag 1 actually consists of cold start exhaust (about the first 100 sec) and running exhaust (about the last 200 sec); while samples in Bag 3 include hot start exhaust and running exhaust. The samples collected in Bag 2 consist solely of hot stabilized running emissions, so the analytical test results of Bag 2 samples are used to generate the new stabilized OG profiles discussed in this memo.

Tedlar bags were used to collect organic gas samples from each phase for GC speciation analysis (MLD SOP#102/103) [4]. Aldehyde and ketone compounds in the exhaust were sampled to 2,4-dinitrophenylhydrazine (DNPH) impregnated cartridges and analyzed by using HPLC (MLD SOP#104) [5]. The methanol and ethanol in the exhaust were obtained by flowing exhaust through deionized water contained in glass impingers and analyzed by using GC (MLD SOP#101) [6].

Over two hundred organic compounds were detected in the Bag 2 samples. For each test vehicle, the speciation profile was calculated by dividing the emissions of each species by the sum of total organic gas emissions. The new profile OG2303 was obtained by averaging the twenty-five speciation profiles for catalyzed gasoline vehicles running with summer-grade E6 fuel. Similarly, the new profile OG2304 was obtained by averaging the sixteen speciation profiles for catalyzed gasoline vehicles running with winter-grade E6 fuel. The non-catalyzed vehicle was excluded from the calculation.

3 Results

The speciation profiles OG2303 (for E6 summer) and OG2304 (for E6 winter) are tabulated in Appendix 3. The ratios of TOG/THC (total organic gases/total hydrocarbon) are 1.083 for OG2303 and 1.108 for OG2304. This ratio can be used to convert THC emission mass to actual weight TOG. The ROG/TOG ratios are 0.6853 and 0.5988 for OG2303 and OG2304, respectively.

- **Comparison of summer (OG2303) and winter (OG2304) profiles**

Methane is the dominant species in the two stabilized profiles: 27.7% in summer profile OG2303, and 36.9% in winter profile OG2304 (Figure 2). Toluene, benzene, ethylene, and isopentane are major species besides methane, and each species weighs about 3-5% of the TOG. Butane is 3.0% in the winter profile (OG2304), nine times higher than in the summer profile (OG2303). However, the winter profile (OG2304) has about 1/3 the amount of 2,2,4-trimethylpentane than in the summer profile (OG2303). The winter versus summer differences of butane and 2,2,4-trimethylpentane in these two running exhaust profiles are consistent with the differences between the E6 winter fuel (OG682) and summer fuel (OG681) profiles, which were developed based on the fuel test results in April 2013. The E6 winter fuel (OG682) consists of more butane but less 2,2,4-trimethylpentane than the E6 summer fuel (OG681), which is due to the change of Reid Vapor Pressure (RVP) [7].

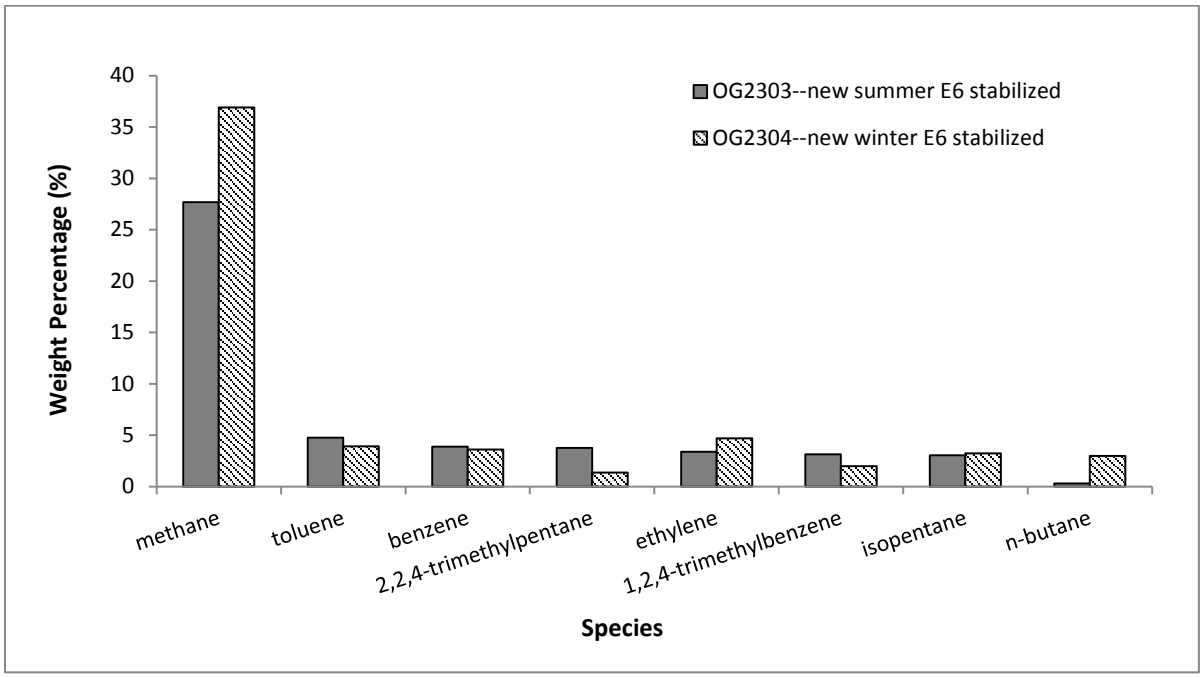

Figure 2. Comparison between new summer and new winter stabilized exhaust profiles by major species

- **New (OG2303 & OG2304) vs. current (OG2104 – OG2109)**

The previous study conducted by Allen et al. [8] concluded from the summer 1994 ARB Surveillance test data that the percentage of exhaust methane increased with decreasing organic gas emissions. As the in-use fleet emission rates have decreased over the years the methane percentage has increased; therefore, the exhaust speciation profiles were developed for each calendar year. In 1999, a series of stabilized profiles, OG2104 through OG2109, were created for vehicles burning ethanol fuel for years 2004 to 2009, respectively. However, these profiles were made by adjusting the MTBE-based fuel stabilized exhaust profiles, not through original source testing [1].

The new profiles proposed in this work are based on actual testing data obtained in VSP17. However, the data analysis does not show the previously observed relationship between methane and TOG or THC emissions as Allen et al. noticed from the 1994 Surveillance project. Therefore, the profiles proposed in this memo, OG2303 (for E6 summer fuel) and OG2304 (for E6 winter fuel), are not created for each specific calendar year. Both of these two profiles are applied to years 2004 through 2009, the period for which E6 was used in California.

The comparisons between the new and current profiles are plotted in Figures 3 and 4. Compared to the current profiles (OG2104-OG2109), the new profiles (OG2303 and OG2304) have higher percentages of C1 (mainly methane), C9 and C10+compounds, but lower percentages of C5- and C6-compounds (Figure 3). The new profiles consist of a much higher methane fraction than the current profiles (28-37% vs. 18-22%). Figure 4 illustrates that alkanes are fairly consistent among both the new and old profiles at 60%, while the new profiles have more aromatics but less alkenes than the current ones.

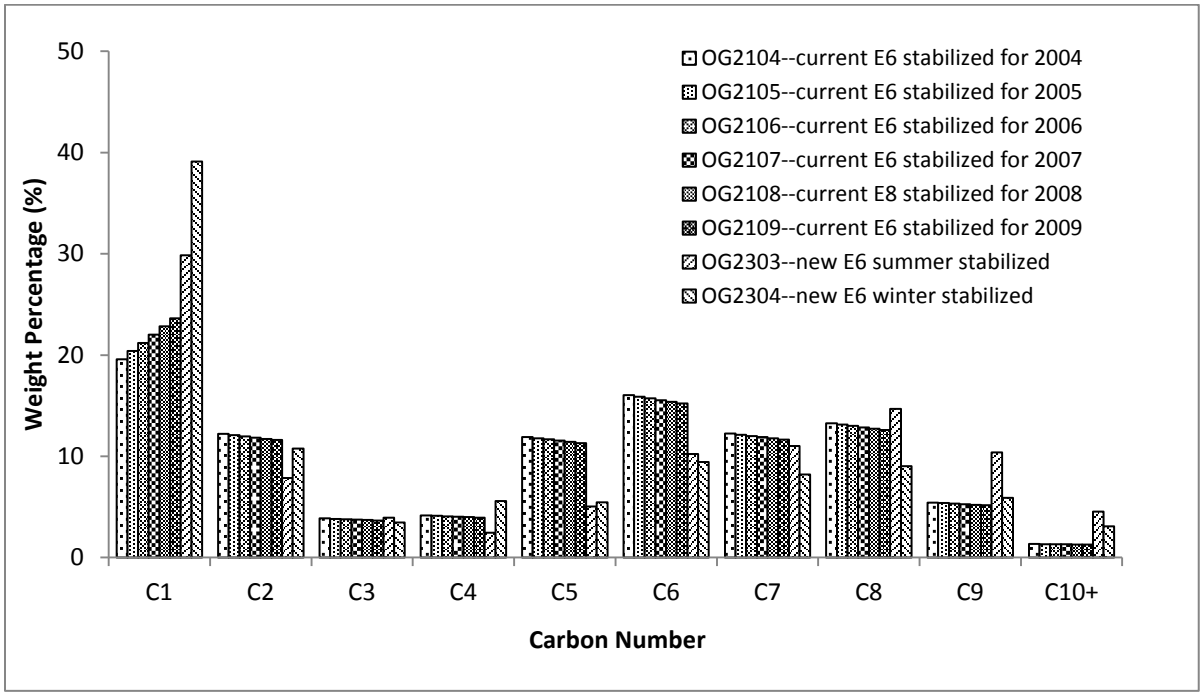

Figure 3. Comparison between current and new stabilized exhaust profiles by carbon number

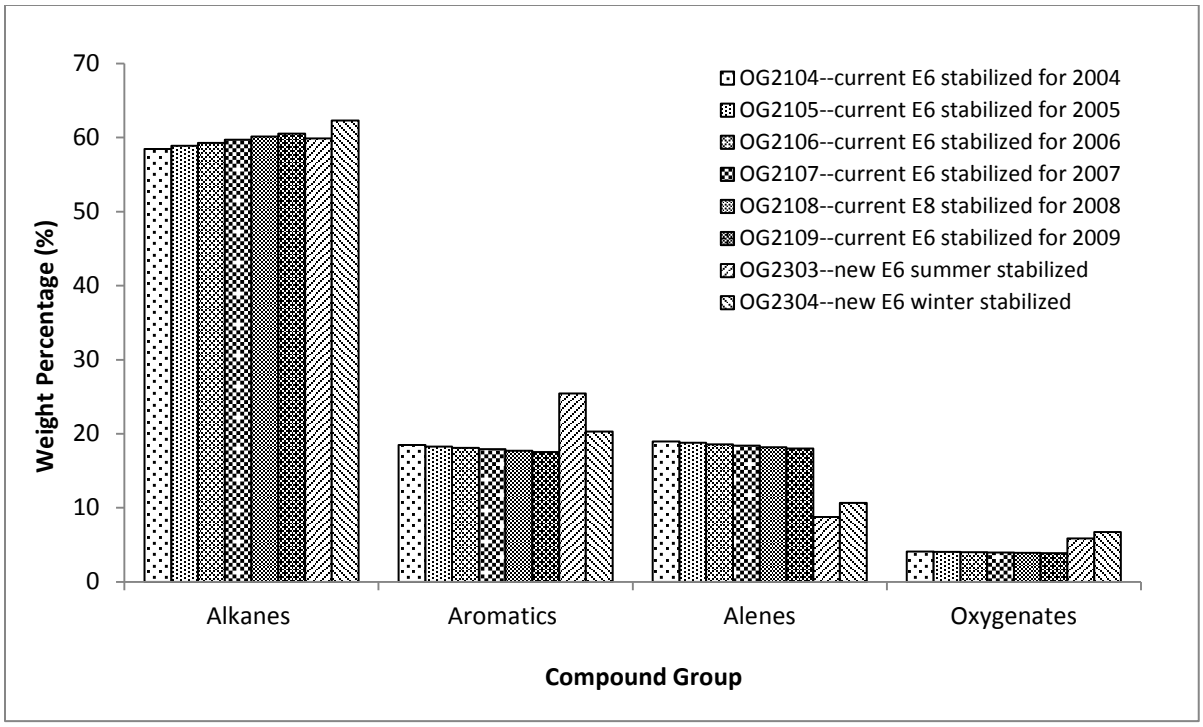

Figure 4. Comparison between current and new stabilized exhaust profiles by compound group

4 Estimated Impacts of the Profile Update on the Emission Inventory

The newly-developed profiles, OG2303 and OG2304, will replace the current profiles OG2104 through OG2109 for years 2004 to 2009, respectively. The new profiles will be used for categories associated with on-road gasoline vehicle hot stabilized exhaust and idle exhaust as E6 fuel was in use during that time period. The summer-grade profile GO2303 will be used during the months of RVP regulatory control periods, while the winter-grade profile OG2304 will be used for the other months of the year. It should be noted that the control period varies for different air basins [9]. The related EIC/SCC codes for the related emission categories are summarized in Appendix 1.

The impacts of the proposed profile update on emissions are estimated for year 2008 as an example in this memo. Based on the 2009 Almanac, statewide annual average TOG emissions from the emission categories to which these profiles are assigned for calendar year 2008 are 136.45 tons/day, which is 19.7% of the total statewide on-road mobile source TOG emissions, and 1.6% of the grand total statewide TOG emissions [10]. Based on the ROG/TOG ratios derived from the new profiles OG2303 and OG2304, the statewide 2008 ROG would be 93.51 and 81.71 tons/day for burning summer and winter fuel, respectively, which is 11.8% and 22.9% lower than the ROG estimated based on the current profile OG2108 (ROG/TOG=0.7767); however, the replacement of the current profile OG2108 with the new summer (OG2303) and winter (OG2304) profiles would cause an increase in benzene emissions by 62.4% and 50.8%, respectively. For toluene emissions, the same profile replacement would cause a decrease of 14.7% (with new summer profile OG2303) and 29.7% (with new winter profile OG2304) (Table 1). The ozone forming potential (OFP) calculated based on the SAPRC07 mechanism [11] is

3.01 for OG2303 and 2.81 for OG2304, lower than the 3.21OFP of the current stabilized profile (OG2108).

Table 1. Emission and reactivity changes resulting from new E6 catalyst gasoline-vehicle stabilized exhaust an idle exhaust categories (2008)

(a) OG2303 (New E6 summer) vs. OG2108 (Current E6 summer/winter for year 2008)

			Current Profile OG2108 (tons/day)	*New Profile OG2303—**summer** (tons/day)*	*Change*	
					Emissions (tons/day)	*Percentage*
Statewide Annual Average Emissions	ROG		105.98	93.51	-12.47	-11.8%
	Toxics	Benzene	3.27	5.31	+2.04	+62.4%
		Toluene	7.61	6.49	-1.12	-14.7%
Ozone forming potential, **MIR** (g O3/g ORG)			3.21	3.01	-0.20	-6.2%

(b) OG2304 (New E6 winter) vs. OG2108 (Current E6 summer/winter for year 2008)

			Current Profile OG2108 (tons/day)	*New Profile OG2304—**winter** (tons/day)*	*Change*	
					Emissions (tons/day)	*Percentage*
Statewide Annual Average Emissions	ROG		105.98	81.71	-24.27	-22.9%
	Toxics	Benzene	3.27	4.93	+1.66	+50.8%
		Toluene	7.61	5.35	-2.26	-29.7%
Ozone forming potential, **MIR** (g O3/g ORG)			3.21	2.81	-0.40	-12.5%

5 Version Control

This section will be completed after management approval and after the CEIDARS FRACTION table and ORGPROFILE table are updated. Version information from CEIDARS FRACTION table will be copied here.

References:

1. Croes, B., et al., *Air Quality Impacts of the Use of Ethanol in California Reformulated Gasoline*, 1999, California Air Resources Board.
2. *Speed versus Time Data for California's Unified Driving Cycle*. 1996; Available from: www.arb.ca.gov/msprog/obdprog/uccycle.doc.
3. Maldonado, H., *Test Cycles Descriptions*, Personal Communication with W. Yang, 2009.
4. CARB, *Standard Operating Procedure No. MLD 102 / 103 (Version 2.2): Procedure for the Determination of C2 to C12 Hydrocarbons in Automotive Exhaust Samples by Gas Chromatography*, 2007: El Monte, CA.
5. CARB, *Standard Operating Procedure No. MLD 104 (Revision 3.0): Procedure for the Determination of Aldehyde and Ketone Compound in Automotive Source Samples by High Performace Liquid Chromatography*, 2006: El Monte, CA.
6. CARB, *Standard Operating Procedure No. MLD 101 (Revision 2.2): Procedure for the Analysis of Automotive Exhaust for Methanol and Ethanol*, 2005: El Monte, CA.
7. *California Code of Regulations, The California Refomulated Gasoline Regulations, Title 13, , Sections 2250-2273.5*: California Air Resources Board.
8. Allen, P., et al., *Speciation of Organic Gas Emissions California Light-Duty Vehicle Exhaust*, 1998, California Air Resources Board: Sacramento, CA.
9. *Title 13, California Code of Regulations, The California Reformulated Gasoline Regulations, Sections 2250-2273.5*.
10. *CEPAM*, 2013, California Air Resources Board.
11. *Titel 17, California Code of Regulations, Division 3, Chapter 1, Subchapter 8.6, Article 1. Maximum Incremental Reactivity Values, Sections 94700-94701*.

Appendix 1. EICs/SCCs associated with catalyzed gasoline-powered vehicle stabilized running exhaust speciation profiles

EIC/SCC	*Names*		
3	EMFAC/DTIM	GASOLINE, ALL VEHICLES	CATALYST RUNNING EXHAUST
15	EMFAC/DTIM	GASOLINE, ALL VEHICLES	CATALYST BUSES
18	EMFAC/DTIM	GASOLINE, ALL VEHICLES	CATALYST IDLE
203	EMFAC/DTIM	GASOLINE, LIGHT-MED DUTY (LMV)	CATALYST RUNNING EXHAUST
215	EMFAC/DTIM	GASOLINE, LIGHT-MED DUTY (LMV)	CATALYST BUSES
218	EMFAC/DTIM	GASOLINE, LIGHT-MED DUTY (LMV)	CATALYST IDLE
303	EMFAC/DTIM	GASOLINE, HEAVY DUTY VEH (HDV)	CAT RUNNING EXHAUST
315	EMFAC/DTIM	GASOLINE, HEAVY DUTY VEH (HDV)	CATALYST BUSES
318	EMFAC/DTIM	GASOLINE, HEAVY DUTY VEH (HDV)	CATALYST IDLE
45807	ON-ROAD VEHICLES	LIGHT DUTY PASSENGER	HOT START
45948	ON-ROAD VEHICLES	LIGHT DUTY PASSENGER	STABILIZED
47175	ON-ROAD VEHICLES	LIGHT DUTY TRUCKS	HOT START
82552	ON-ROAD VEHICLES	LIGHT DUTY PASSENGER	CATALYST STABILIZED
82586	ON-ROAD VEHICLES	LIGHT/MEDIUM TRUCKS	CATALYST STABILIZED
83154	ON-ROAD VEHICLES	HEAVY GAS TRUCKS	CATALYST STABILIZED
84160	ON-ROAD VEHICLES	LIGHT DUTY TRUCKS-1	CATALYST STABILIZED
84376	ON-ROAD VEHICLES	MEDIUM DUTY TRUCKS	CATALYST STABILIZED
84525	ON-ROAD VEHICLES	LIGHT HEAVY DUTY TRUCKS-1	CATALYST STABILIZED
84673	ON-ROAD VEHICLES	MEDIUM HEAVY GAS TRUCKS	CATALYST STABILIZED
86231	ON-ROAD VEHICLES	LT. DUTY TRUCKS-2	CATALYST HOT STABILIZED
86421	ON-ROAD VEHICLES	LT.HVY.DTY TRUCKS-1	CATALYST IDLE EXHAUST
86546	ON-ROAD VEHICLES	LT.HVY.DTY TRUCKS-2	CATALYST HOT STABILIZED
86553	ON-ROAD VEHICLES	LT.HVY.DTY TRUCKS-2	CATALYST IDLE EXHAUST
86652	ON-ROAD VEHICLES	MEDIUM HEAVY DUTY GAS	CATALYST IDLE EXHAUST
86777	ON-ROAD VEHICLES	HEAVY HEAVY DUTY GAS	CATALYST HOT STABILIZED
86785	ON-ROAD VEHICLES	HEAVY HEAVY DUTY GAS	CATALYST IDLE EXHAUST
86975	ON-ROAD VEHICLES	MOTORCYCLES (MCY)	CATALYST HOT STABILIZED
87155	ON-ROAD VEHICLES	HEAVY DUTY GAS URBAN	CATALYST HOT STABILIZED
87320	ON-ROAD VEHICLES	SCHOOL BUSES (SB)	CATALYST HOT STABILIZED
87536	ON-ROAD VEHICLES	MOTOR HOMES (MH)	CATALYST HOT STABILIZED
71073411000000	ON-ROAD VEHICLES	LIGHT DUTY PASSENGER	CATALYST STABILIZED
72073411000000	ON-ROAD VEHICLES	LIGHT DUTY PASSENGER	CATALYST IDLE EXHAUST
72273411000000	ON-ROAD VEHICLES	LIGHT/MEDIUM TRUCKS	CATALYST STABILIZED
72373411000000	ON-ROAD VEHICLES	LT. DUTY TRUCKS-1	CATALYST STABILIZED
72473411000000	ON-ROAD VEHICLES	LT. DUTY TRUCKS-1	CATALYST IDLE EXHAUST
73073411000000	ON-ROAD VEHICLES	LT. DUTY TRUCKS-2	CATALYST HOT STABILIZED

73273411000000	ON-ROAD VEHICLES	LT. DUTY TRUCKS-2	CATALYST IDLE EXHAUST
73273511000000	ON-ROAD VEHICLES	MEDIUM TRUCKS	CATALYST STABILIZED
73373411000000	ON-ROAD VEHICLES	MEDIUM TRUCKS	CATALYST IDLE EXHAUST
73373511000000	ON-ROAD VEHICLES	HEAVY GAS TRUCKS	CATALYST STABILIZED
73473411000000	ON-ROAD VEHICLES	LT.HVY.DTY TRUCKS-1	CATALYST STABILIZED
73473511000000	ON-ROAD VEHICLES	LT.HVY.DTY TRUCKS-1	CATALYST IDLE EXHAUST
73673411000000	ON-ROAD VEHICLES	LT.HVY.DTY TRUCKS-2	CATALYST HOT STABILIZED
73673511000000	ON-ROAD VEHICLES	LT.HVY.DTY TRUCKS-2	CATALYST IDLE EXHAUST
75073411000000	ON-ROAD VEHICLES	MED. HVY. DTY TRUCKS	CATALYST STABILIZED
76273411000000	ON-ROAD VEHICLES	MED. HVY. DTY TRUCKS	CATALYST IDLE EXHAUS
77073411000000	ON-ROAD VEHICLES	HVY. HVY. DTY TRUCKS	CATALYST HOT STABILIZED
77073511000000	ON-ROAD VEHICLES	HVY. HVY. DTY TRUCKS	CATALYST IDLE EXHAUST
77173411000000	ON-ROAD VEHICLES	MOTORCYCLES (MCY)	CATALYST HOT STABILIZED
77173511000000	ON-ROAD VEHICLES	MOTORCYCLES (MCY)	CATALYST IDLE EXHAUST
77673411000000	ON-ROAD VEHICLES	HVY. GAS URBAN BUSES	CATALYST HOT STABILIZED
77673511000000	ON-ROAD VEHICLES	HVY. GAS URBAN BUSES	CATALYST IDLE EXHAUST
77773411000000	ON-ROAD VEHICLES	SCHOOL BUSES (SB)	CATALYST HOT STABILIZED
77773511000000	ON-ROAD VEHICLES	SCHOOL BUSES (SB)	CATALYST IDLE EXHAUST
78073411000000	ON-ROAD VEHICLES	SCHOOL BUSES GASOLINE (SBG)	CATALYST HOT STABILIZED
78073511000000	ON-ROAD VEHICLES	SCHOOL BUSES GASOLINE (SBG)	CATALYST IDLE EXHAUST

Appendix 2. Test vehicle and fuel information

Vehicle No.	*Model_Year*	*Manufacturer*	*Model_Type*	*Equipped with Catalyzed Converter*	*Fuel_Type*
218	2000	GM	LS2	Yes	Summer Commercial Phase 3 Gasoline
219	1987	NISS	P/U	Yes	
220	1992	MITS	PU	Yes	
221	1997	NISS	QUEST XE	Yes	
222	1998	CHRY	GRANDVOYAGER	Yes	
223	1996	TOTA	CAMRY LE	Yes	
224	1994	NISS	G20	Yes	
225	2002	HOND	ACCORD LX	Yes	
226	1999	VOLK	NEW BEETLE	Yes	
227	1994	FORD	VILLAGER LS	Yes	
228	1998	FORD	CONTOUR	Yes	
229	1995	GM	SUBURBAN LT	Yes	
230	1991	MB	300SEL	Yes	
231	2001	GM	MALIBU	Yes	
233	1998	MAZD	PROTEGE	Yes	
235	2002	FORD	MUSTANG	Yes	
242	1996	GM	CAVALIER	Yes	
244	1998	FORD	NAVIGATOR	Yes	
246	1996	GM	TAHOE	Yes	
247	2000	TOTA	CELICA GT-S	Yes	
248	1994	GM	CAVALIER	Yes	
251	1994	CHRY	GRAND CHEROKEE	Yes	
254	1998	FORD	MUSTANG SALEEN	Yes	
259	1999	HOND	CIVIC CX	Yes	
260	2000	CHRY	NEON	Yes	
265	1994	FORD	RANGER	Yes	Winter Commercial Phase 3 Gasoline
266	1984	CHRY	ARIES	Yes	
271	2001	VOLK	GTI	Yes	
272	1988	HOND	INTEGRA	Yes	
274	2001	SAAB	95 SE	Yes	
277	1996	FORD	WINDSTAR GL	Yes	
278	1999	NISS	FRONTIER XE	Yes	
280	1998	HOND	CIVIC DX	Yes	
281	2001	GM	LUMINA	Yes	
282	1999	GM	GRAND PRIX GT	Yes	
*284	1980	GM	P/U	No	
286	1991	FORD	ESCORT GT	Yes	
292	1992	CHRY	ACCLAIM	Yes	
294	1998	CHRY	SEBRING	Yes	
299	1996	FORD	TAURUS GL	Yes	
301	1998	FORD	RANGER XLT	Yes	
302	1985	HOND	CIVIC CRX	Yes	

**The test results of this non-catalyzed vehicle were not included in the profile development for catalyzed vehicles.*

Appendix 3. OG speciation profiles for catalyzed gasoline-powered vehicle stabilized running exhaust burning E6 summer and winter fuels

Species Name	*SAROAD*	*Weight Percentage, %*	
		OG2303 Catalyzed Gasoline-Powered Vehicle Stabilized Exhaust (E6 Summer)	*OG2304 Catalyzed Gasoline-Powered Vehicle Stabilized Exhaust (E6 Winter)*
(2-methylpropyl)benzene	45235	0.081527	0.007325
1-(1,1-dimethylethyl)-3,5-dimethylbenzene	45256	0.046830	0.004371
1,2,3,4-tetramethylbenzene	91109	0.040088	0.026153
1,2,3,5-tetramethylbenzene	91104	0.253842	0.251723
1,2,3-trimethylbenzene	45225	0.728718	0.542883
1,2,4,5-tetramethylbenzene	91103	0.162907	0.145122
1,2,4-trimethylbenzene	45208	3.159537	2.005976
1,2,4-trimethylcyclopentane	43400	0.054036	0.047408
1,2-butadiene (methylallene)	43221	0.000777	0.012689
1,2-diethylbenzene (ortho)	98154	0.003134	0.006997
1,2-dimethyl-3-ethylbenzene	45254	0.014124	0.005431
1,2-dimethyl-4-ethylbenzene	45252	0.321799	0.293271
1,2-propadiene	43208	0.055392	0.029722
1,3,5-trimethylbenzene	45207	0.674134	0.456899
1,3,5-trimethylcyclohexane	98061	0.020355	0.017572
1,3-butadiene	43218	0.242726	0.198716
1,3-butadiyne	43222		0.004576
1,3-diethylbenzene (meta)	45113	0.055441	0.033481
1,3-dimethyl-2-ethylbenzene	45253	0.046948	0.012537
1,3-dimethyl-4-ethylbenzene	45251	0.217076	0.122260
1,3-dimethyl-5-ethylbenzene	45257	0.434780	0.310653
1,3-dipropylbenzene	45237	0.058326	0.068665
1,4-diethylbenzene (para)	45114	0.082855	0.074276
1,4-dimethyl-2-ethylbenzene	45250	0.246598	0.194426
1-butene	43213	0.174689	0.257032
1-ethyl-2n-propylbenzene	98179	0.001392	0.004469
1-ethyl-4-methylcyclohexane	92001	0.023413	0.005295
1-hexene	43245	0.005398	0.026631
1-methyl-2-ethylbenzene	99915	0.398895	0.335250
1-methyl-2-isopropylbenzene	91096	0.020631	0.016281
1-methyl-2-n-butylbenzene	45243	0.026293	0.016823
1-methyl-2-n-propylbenzene	98178	0.072985	0.040204
1-methyl-3-ethylbenzene	99912	1.449800	1.154466
1-methyl-3-isopropylbenzene	98153	0.010753	0.006845
1-methyl-3-n-propylbenzene	98152	0.328589	0.267025
1-methyl-4-ethylbenzene	99914	0.461214	0.408819
1-methyl-4-isopropylbenzene	91094	0.003956	0.003401
1-methyl-4-n-propylbenzene	98182	0.008961	0.021633
1-methylcyclopentene	92000	0.015453	0.238498
1-nonene	43267		0.005167
1-octene	43265		0.001142
1-pentene	43224	0.020651	0.071340
1-tert-butyl-2-methylbenzene	45244	0.003587	0.003345
2,2,3-trimethylbutane	43160	0.003480	0.003810
2,2,4-trimethylheptane	98174	0.025870	0.005339
2,2,4-trimethylhexane	45222	0.025154	0.001202

Species Name	*SAROAD*	*Weight Percentage, %*	
		OG2303 Catalyzed Gasoline-Powered Vehicle Stabilized Exhaust (E6 Summer)	*OG2304 Catalyzed Gasoline-Powered Vehicle Stabilized Exhaust (E6 Winter)*
2,2,4-trimethylpentane	43276	3.769925	1.355051
2,2,5-trimethylheptane	43252	0.164013	0.041986
2,2,5-trimethylhexane	98033	1.660483	0.156472
2,2-dimethylbutane	43291	0.402086	0.281424
2,2-dimethylhexane	98138		0.008767
2,2-dimethyloctane	98175	0.030777	0.009457
2,2-dimethylpentane	90042		0.004274
2,3,3-trimethylpentane	43280		0.019611
2,3,4-trimethylpentane	43279	1.349811	0.367775
2,3,5-trimethylhexane	98141	0.048677	0.013036
2,3-dimethyl-1-butene	43234		0.033323
2,3-dimethylbutane	98001	0.792349	0.637659
2,3-dimethylhexane	98139	0.476031	0.076832
2,3-dimethyloctane	98183	0.021097	0.009355
2,3-dimethylpentane	43274	1.225835	0.821724
2,4,4-trimethyl-2-pentene	98055	0.021763	0.000789
2,4,4-trimethylhexane	45223	0.068837	0.010488
2,4-dimethyl-1-pentene	90063		0.002412
2,4-dimethylheptane	98142	0.108185	0.077641
2,4-dimethylhexane	43277	0.567796	0.223548
2,4-dimethyloctane	98149	0.063893	0.006733
2,4-dimethylpentane	43271	0.867762	0.496317
2,5-dimethylhexane	43278	0.483680	0.301937
2,5-dimethyloctane	98176	0.013695	0.007305
2,6-dimethylheptane	98157	0.050398	0.015919
2,6-dimethyloctane	98177	0.003323	0.005792
2-methyl-1-butene	43225	0.061190	0.148018
2-methyl-1-pentene	98040	0.016644	0.005008
2-methyl-2-butene	43228	0.137153	0.197808
2-methyl-2-hexene	90028	0.002821	
2-methyl-2-pentene	98004	0.014020	0.003156
2-methyl-2-propenal	43506	0.008895	0.019617
2-methylheptane	98140	0.300165	0.330821
2-methylhexane	43275	0.850466	0.614310
2-methylindan	91108	0.155142	0.168540
2-methylnonane	90047	0.398006	0.137356
2-methylpentane	43229	1.581986	1.381234
2-methyl-trans-3-hexene	91006	0.000940	0.001052
3,3-dimethyl-1-butene	98169	0.086677	0.074413
3,3-dimethylhexane	98171	0.002678	0.002131
3,3-dimethyloctane	98184	0.015631	0.007284
3,3-dimethylpentane	90040	0.028383	0.032832
3,4-dimethyl-1-pentene	90075		0.002665
3,4-dimethylhexane	98150	0.030505	0.016673
3,5-dimethylheptane	98144	0.059068	0.048229
3-ethyl-2-pentene	98007	0.132919	
3-ethylpentane	43300	0.029724	0.134874
3-methyl-1-butene	43223	0.007412	0.017423

Species Name	*SAROAD*	*Weight Percentage, %*	
		OG2303 Catalyzed Gasoline-Powered Vehicle Stabilized Exhaust (E6 Summer)	*OG2304 Catalyzed Gasoline-Powered Vehicle Stabilized Exhaust (E6 Winter)*
3-methyl-1-hexene	90030		0.052516
3-methyl-1-pentene	43211	0.004082	0.005630
3-methyl-cis-2-hexene	90029	0.068895	
3-methyl-cis-2-pentene	98163	0.006648	0.004121
3-methylcyclopentene	43272	0.005991	0.002310
3-methylheptane	43298	0.399430	0.323467
3-methylhexane	43295	0.884752	0.581113
3-methyloctane	98172	0.123591	0.075348
3-methylpentane	43230	1.044662	0.850120
3-methyl-trans-2-pentene	43270	0.017263	0.007367
4-methyl-1-pentene	98135		0.005793
4-methylheptane	43297	0.071748	0.051383
4-methylindan	91107	0.002682	0.015954
4-methyloctane	98173	0.321994	0.175938
4-methyl-trans-2-hexene	90031	0.000806	0.001332
4-methyl-trans-2-pentene	43293	0.027489	0.004917
5-methylindan	91106	0.110123	0.150695
acetaldehyde	43503	0.900112	1.639909
acetone	43551	0.850055	0.622981
acetylene	43206	0.562078	0.737721
acrolein	43505	0.001418	0.005559
benzaldehyde	45501	0.196768	0.313300
benzene	45201	3.890986	3.614598
butyraldehyde	43510	0.278587	0.165390
cis-1,2-dimethylcyclohexane	91055	0.097780	0.124814
cis-1,3-dimethylcyclohexane	98180	0.100406	0.057920
cis-1,3-dimethylcyclopentane	91018	0.160312	0.150317
cis-1,trans-2,3-trimethylcyclopentane	91038	0.019335	0.020406
cis-1-methyl-3-ethylcyclopentane	90080	0.023877	0.024562
cis-2-butene	43217	0.052624	0.072825
cis-2-heptene	91028	0.016994	0.004142
cis-2-hexene	98035		0.004412
cis-2-octene	43266	0.004347	
cis-2-pentene	43227	0.019228	0.052091
crotonaldehyde	98156	0.016630	0.115658
cyclohexane	43248	0.309910	0.324518
cyclohexene	43273	0.003879	0.072454
cyclopentane	43242	0.090558	0.075484
cyclopentene	43292	0.006391	0.018761
ethane	43202	2.927162	2.611943
ethanol	43302	0.052267	1.055577
ethylbenzene	45203	1.119104	0.802767
ethylcyclohexane	43288	0.032297	0.031740
ethylcyclopentane	98057	0.043304	
ethylene	43203	3.397285	4.702096
formaldehyde	43502	2.148524	2.163643
hexaldehyde	98159	0.365898	0.179029
indan	98044	0.107456	0.166211

Species Name	*SAROAD*	*Weight Percentage, %*	
		OG2303 Catalyzed Gasoline-Powered Vehicle Stabilized Exhaust (E6 Summer)	*OG2304 Catalyzed Gasoline-Powered Vehicle Stabilized Exhaust (E6 Winter)*
isobutane	43214	0.097842	0.498401
isobutylene	43215	1.021746	0.985936
isopentane	98132	3.066590	3.225566
isoprene	43243	0.066677	0.023082
isopropylbenzene (cumene)	98043	0.020091	0.020470
methane	43201	27.691971	36.889619
methyl alcohol	43301	0.020460	0.063320
methyl ethyl ketone (mek)	43552	0.150660	0.106671
methyl t-butyl ether (mtbe)	43378	0.467993	0.004079
methylcyclohexane	43261	0.730725	0.303706
methylcyclopentane	43262	0.841109	0.861391
m-xylene	45205	2.267152	2.090324
naphthalene	98046	0.368544	0.136460
n-butane	43212	0.316705	2.997849
n-decane	43238	0.344923	0.293857
n-dodecane	43255	0.127582	0.050781
n-heptane	43232	0.638928	0.447108
n-hexane	43231	0.777615	0.759503
n-nonane	43235	0.644852	0.124780
n-octane	43233	0.213755	0.254167
n-pentane	43220	0.943338	1.312607
n-pentylbenzene	45255	0.007359	0.017655
n-propylbenzene	45209	0.227370	0.078954
n-undecane	43241	0.136448	0.070378
n-valeraldehyde	98200	0.105116	0.034767
o-xylene	45204	1.611576	1.174892
propane	43204	0.632941	0.558541
propionaldehyde	43504	0.189806	0.157532
propylene	43205	2.197042	2.098877
p-xylene	45206	1.195047	1.019910
styrene	45220	0.218529	0.094347
tolualdehyde	45502	0.109363	0.090498
toluene	45202	4.754084	3.922254
trans-1,2-dimethylcyclopentane	91021	0.118821	0.145395
trans-1,3-dimethylcyclohexane	98059	0.038340	0.031176
trans-1,3-dimethylcyclopentane	91019	0.171939	0.159661
trans-1,3-pentadiene	90100		0.002773
trans-1,4-dimethylcyclohexane	98181	0.036009	0.036042
trans-1-methyl-3-ethylcyclopentane	91044	0.050472	0.043790
trans-2-butene	43216	0.100621	0.144476
trans-2-heptene	91026	0.095426	0.007939
trans-2-hexene	98034	0.014036	0.034343
trans-2-octene	43263	0.008692	0.005939
trans-2-pentene	43226	0.060527	0.270345
trans-3-heptene	98006	0.000672	0.003994
trans-3-hexene	98136	0.020823	0.006454
trans-4-octene	43250		0.004339
Total		*100.000000*	*100.000000*