**Organic Gas Speciation Profiles for**
**Catalyzed Gasoline-Powered Vehicle Start Exhaust—E6 Fuel (OG2301 & OG2302)**

Wenli Yang, PhD, PE

*Air Quality Planning and Science Division*

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## 1 Introduction

This memo addresses an update of the current gasoline vehicle start exhaust profile assigned to 2004 through 2009 calendar year inventories (OG664) with new two new profiles, OG2301(summer-grade E6 fuel) and OG2302 (winter-grade E6 fuel). The current profile was derived for E6 gasoline fuel by adjusting the start exhaust profile for MTBE-based fuel [1]; it was not based on source testing measurements. The new profiles are based on measurements. Minor to moderate percentage changes in toxic emission estimates (i.e. benzene and toluene) result from this update.

The updated start profiles proposed in this memo, OG2301 (Catalyzed gasoline vehicle start exhaust—summer-grade E6 fuel) and OG2302 (Catalyzed gasoline vehicle start exhaust—winter-grade E6 fuel), are based on source testing results. In 2005 and 2006, CARB conducted the Seventeenth Vehicle Surveillance program (VSP-17) 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 VSP-17, a total of forty-two in-use vehicles were randomly selected for exhaust organic gas speciation tests. Twenty-five of these vehicles (all equipped with catalyst converter) were fueled with summer grade E6 gasoline; and the other seventeen (sixteen equipped with catalyst converter) were fueled with winter grade E6 gasoline.

## 2 Methodology

In the VSP-17 speciation tests, the organic gases from tailpipe exhaust were sampled as the vehicles were running on the unified cycle (UC), which was developed by CARB in 1992 as a dynamometer driving schedule for light-duty vehicles.

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

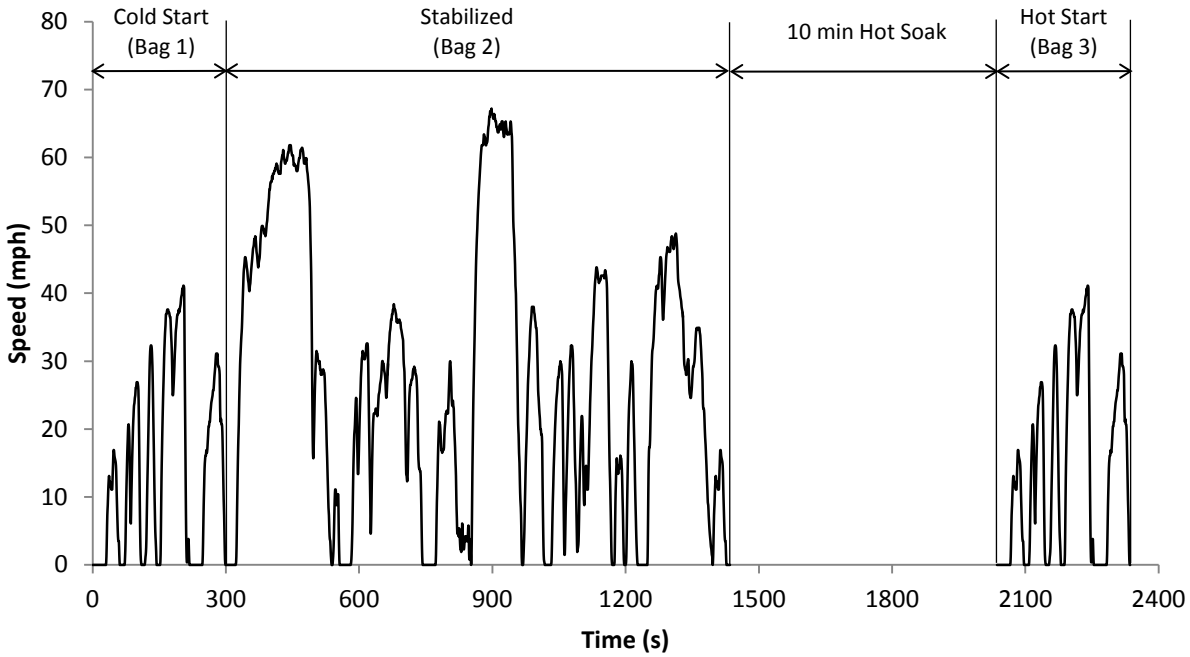


**Figure 1. Unified Cycle**

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 sample collected in Bag 1 actually consists of cold start (about the first 100 s) exhaust and running (about the last 200 s) exhaust; while the sample in Bag 3 includes hot start (about the first 100 s) exhaust and running (about the last 200 s) exhaust. Thus, the differences between Bag 1 and Bag 3 are emissions generated from start operations only. Because the processes of cold start and hot start are not specified in the CARB emission inventory, the general start exhaust speciation profile is discussed in this work.

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

Over two hundred organic compounds were detected in the Bag 1 and Bag 3 samples. For each test vehicle, the differences between Bag 1 and Bag 3 emissions were calculated for each organic gas species with negative values set to zero. The speciation profile for each vehicle was then obtained by dividing the emissions of each species by the sum of all emissions. The new profile OG2301 was calculated by averaging the twenty-five speciation profiles for catalyzed gasoline vehicles running with summer-grade E6 fuel; and the new profile OG2302 was calculated by averaging the sixteen speciation profiles for catalyzed gasoline vehicles running with winter-grade E6 fuel.

## 3 Results

The details of profiles OG2301 (E6 summer) and OG2302 (E6 winter) are tabulated in Appendix 1. The ratios of TOG/THC (total organic gases/total hydrocarbon) are 1.044 for OG2301 and 1.054 for OG2302. This ratio can be used to convert THC emission mass to actual weight TOG. The ROG/TOG ratios are 0.9133 and 0.8811 for OG2301 and OG2302, respectively.

- **Summer (OG2301) vs. winter (OG2302)**

The most abundant species in the two profiles include: ethylene (about 8%), toluene (about 8%), methane (7-10%), and propene (4-5%). The summer profile (OG2301) has 3.6% less methane and 1.4% less butane than the winter profile (OG2302); but the content of 2,2,4-trimethylpentane in the summer profile (OG2301) is 2.2% more than in the winter profile (OG2302). The differences of butane and 2,2,4-trimethylpentane in these two start exhaust profiles are consistent with the differences between summer and winter fuel profiles (i.e. as a consistency check comparison). The E6 summer fuel (OG681) consists of 3.0% less butane but 2.8% more 2,2,4-trimethylpentane than the E6 winter fuel (OG682), which is due to the change of Reid Vapor Pressure (RVP).

- **New (OG2301 & OG2302) vs. current (OG664)**

The current start profile used for 2004 and later years is OG664. This profile was not based on source testing measurements; rather, it was created for E6 gasoline fuel by adjusting the start exhaust profile for MTBE-based fuel [1]. However, the two new start profiles OG2301 and OG2302 are based on real testing data. Compared with OG664, the new profiles have higher methane (7-10% vs. 5%), ethylene (8% vs. 7%), and propylene (4-5% vs. 3%). The content of m-xylene, ethanol, C5 alkanes (e.g. n-pentane and isopentane), C6 alkanes (e.g. 2-methylpentane and 3-methylpentane) and methylcyclopentane are about 1-2% less in the new profiles than in OG664. The fraction of 2,2,4-trimethylpentane is about 2% less in OG2301 than in OG664 (Figure 1).

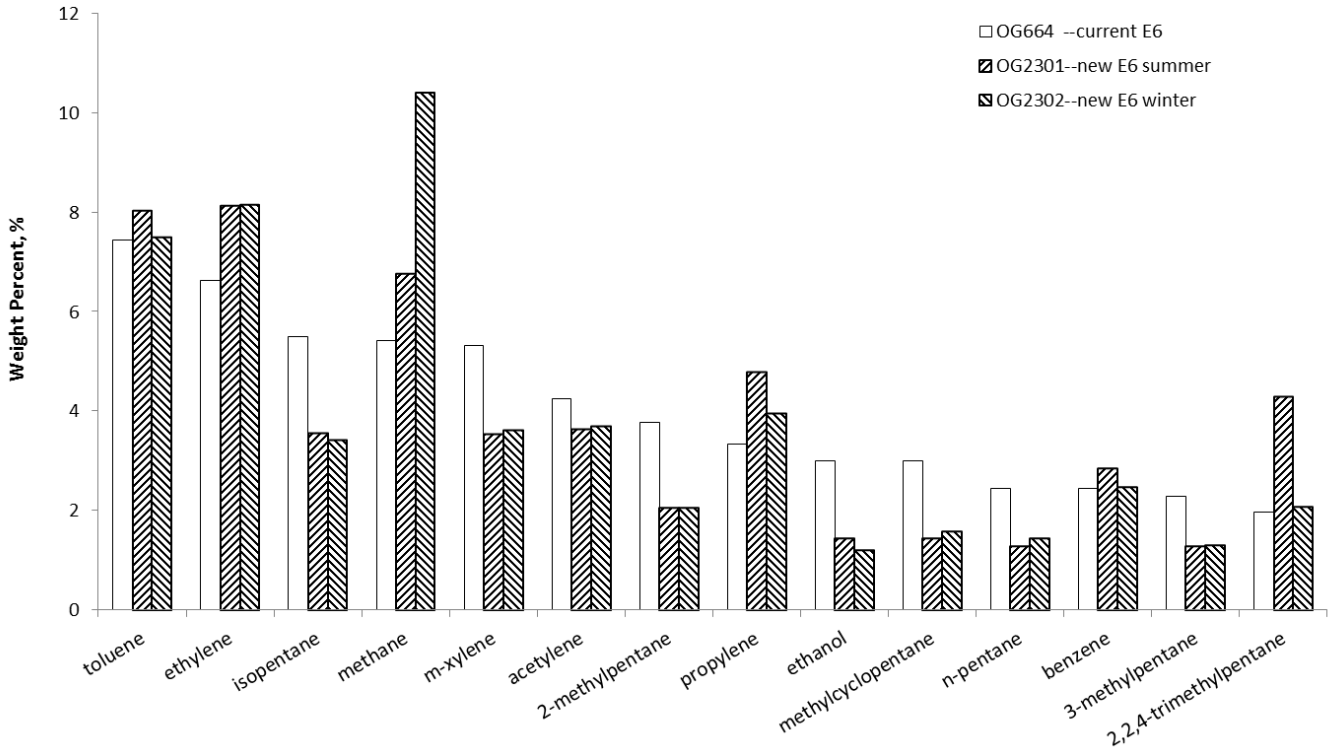


**Figure 2. Comparison of selected species between OG664 and OG2301/OG2302**

## 4 Estimated Impacts of the Profile Update on the Emission Inventory

The newly-developed profiles, OG2301 and OG2302, will replace the current profile OG664 for categories associated with on-road gasoline vehicle start emissions for years 2004 to 2009 as E6 fuel was in use during this time period. The summer-grade profile (OG2301) will be used during the months of RVP regulatory control periods; while the winter-grade profile (OG2302) will be used for other months of the year. It should be noted that the control period varies for different air basins [2]. The related EIC/SCC codes for these emission processes are summarized in Appendix 2.

Based on the 2009 Almanac, statewide annual average TOG emissions for calendar year 2008 from the emission categories to which these profiles will be assigned are 128.10 tons/day, which is 18.5% of the total statewide on-road mobile source TOG emissions, and 1.5% of the grand total statewide TOG emissions [3]. Based on the ROG/TOG ratios derived from the new profiles OG2301 and OG2302, the statewide 2008 ROG will be 116.99 and 112.87 tons/day for summer and winter, respectively, which is 2.3 and 5.8% lower than the ROG estimated based on the current profile OG664 (ROG/TOG=0.9349); however, the replacement of the current OG664 with the new summer (OG2301) and winter (OG2302) profiles will cause a 16.3% and 1.6% increase in benzene emissions and 7.9% and 0.7% increase in toluene emissions, respectively (Table 1). The ozone forming potential (OFP) calculated based on the SAPRC07 mechanism [4] is 4.33 for OG2301 and 4.22 for OG2302, which are higher than the OFP of the current start profile (OG664) 4.05.

**Table 1. Changes in 2008 emissions of organic gas species for catalyst gasoline-vehicle start exhaust categories**

**(a) OG2301 (New E6 summer) vs. OG664 (Current E6)**

| *Statewide Annual Ave. Emissions* | | *OG664 Current E6 (tons/day)* | *OG2301 New E6 Summer (tons/day)* | *Change* | |
|---|---|---|---|---|---|
| | | | | *Emission (tons/day)* | *Percentage* |
| ROG | | 119.76 | 116.99 | -2.77 | -2.3% |
| Ozone forming potential, MIR (g O3/g ORG) | | 4.05 | 4.33 | +0.28 | +6.9% |
| Toxics | Benzene | 3.12 | 3.63 | +0.51 | +16.3% |
| | Toluene | 9.53 | 10.28 | +0.75 | +7.9% |

**(b) OG2302 (New E6 winter) vs. OG664 (Current E6)**

| *Statewide Annual Ave. Emissions* | | *OG664 Current E6 (tons/day)* | *OG2302 New E6 Winter (tons/day)* | *Change* | |
|---|---|---|---|---|---|
| | | | | *Emission (tons/day)* | *Percentage* |
| ROG | | 119.76 | 112.87 | -6.89 | -5.8% |
| Ozone forming potential, MIR (g O3/g ORG) | | 4.05 | 4.22 | +0.17 | +4.2% |
| Toxics | Benzene | 3.12 | 3.17 | +0.05 | +1.6% |
| | Toluene | 9.53 | 9.60 | +0.07 | +0.7% |

## 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. *Title 13, California Code of Regulations, The California Reformulated Gasoline Regulations, Sections 2250-2273.5*.
3. *CEPAM*, 2013, California Air Resources Board.
4. *Titel 17, California Code of Regulations, Division 3, Chapter 1, Subchapter 8.6, Article 1. Maximum Incremental Reactivity Values, Sections 94700-94701*.

**Appendix 1. OG speciation profiles for catalyzed gasoline-powered vehicle start exhaust burning E6 summer and winter fuels**

| *Species Name* | *SAROAD* | *Weight Percentage, %* | |
|---|---|---|---|
| | | *OG2301 Catalyzed Gasoline-Powered Vehicle Start Exhaust (E6 Summer)* | *OG2302 Catalyzed Gasoline-Powered Vehicle Start Exhaust (E6 Winter)* |
| (1a,2a,3b)-1,2,3-trimethylcyclopentane | 91038 | 0.089733 | 0.094376 |
| (1-methylethyl)benzene | 98043 | 0.088174 | 0.090257 |
| (2-methylpropyl)benzene | 45235 | 0.048577 | 0.019629 |
| 1-(1,1-dimethylethyl)-2-methylbenzene | 45244 | 0.012500 | 0.004415 |
| 1-(1,1-dimethylethyl)-3,5-dimethylbenzene | 45256 | 0.028366 | 0.017568 |
| 1,2,3,4-tetramethylbenzene | 91109 | 0.037107 | 0.021025 |
| 1,2,3,5-tetramethylbenzene | 91104 | 0.131098 | 0.137987 |
| 1,2,3-trimethylbenzene | 45225 | 0.399651 | 0.423476 |
| 1,2,4,5-tetramethylbenzene | 91103 | 0.090073 | 0.096339 |
| 1,2,4-trimethylbenzene | 45208 | 1.894830 | 2.018221 |
| 1,2,4-trimethylcyclopentane | 43400 | 0.149508 | 0.158752 |
| 1,2-butadiene | 43221 | 0.017368 | 0.062350 |
| 1,2-diethylbenzene | 98154 | 0.015900 | 0.024003 |
| 1,2-dimethyl-3-ethylbenzene | 45254 | 0.089727 | 0.024083 |
| 1,2-dimethyl-4-ethylbenzene | 45252 | 0.197150 | 0.246594 |
| 1,2-propadiene | 43208 | 0.141279 | 0.195041 |
| 1,3,5-trimethylbenzene | 45207 | 0.616244 | 0.674683 |
| 1,3,5-trimethylcyclohexane | 98061 | 0.085037 | 0.063941 |
| 1,3-butadiene | 43218 | 0.709925 | 0.586457 |
| 1,3-butadiyne | 43222 | 0.008719 | 0.023900 |
| 1,3-diethylbenzene | 45113 | 0.103212 | 0.119672 |
| 1,3-dimethyl-2-ethylbenzene | 45253 | 0.053778 | 0.047800 |
| 1,3-dimethyl-4-ethylbenzene | 45251 | 0.157191 | 0.175542 |
| 1,3-dimethyl-5-ethylbenzene | 45257 | 0.276527 | 0.279776 |
| 1,3-di-n-propylbenzene | 45237 | 0.026111 | 0.019345 |
| 1,4-diethylbenzene | 45114 | 0.107060 | 0.104723 |
| 1,4-dimethyl-2-ethylbenzene | 45250 | 0.191814 | 0.195673 |
| 1-buten-3-yne | 98134 | 0.019968 | |
| 1-butene | 43213 | 0.705141 | 0.726753 |
| 1-butyne | 98131 | 0.000450 | 0.002242 |
| 1-ethyl-2-n-propylbenzene | 98179 | 0.011624 | 0.013047 |
| 1-ethyl-tert-butyl-ether | 99998 | 0.000992 | |
| 1-hexene | 43245 | 0.068046 | 0.075799 |
| 1-methyl-2-(1-methylethyl)benzene | 91096 | 0.076082 | 0.061953 |
| 1-methyl-2-ethylbenzene | 99915 | 0.430488 | 0.458361 |
| 1-methyl-2-n-butylbenzene | 45243 | 0.021207 | 0.026077 |
| 1-methyl-2-n-propylbenzene | 98178 | 0.082760 | 0.072360 |
| 1-methyl-3-(1-methylethyl)benzene | 98153 | 0.058378 | 0.031747 |
| 1-methyl-3-ethylbenzene | 99912 | 1.271630 | 1.384503 |
| 1-methyl-3-n-propylbenzene | 98152 | 0.260473 | 0.261875 |
| 1-methyl-4-(1-methylethyl)benzene | 91094 | 0.026227 | 0.017737 |
| 1-methyl-4-ethylbenzene | 99914 | 0.543483 | 0.594561 |
| 1-methyl-4-ethylcyclohexane | 92001 | 0.053647 | 0.069157 |

| *Species Name* | *SAROAD* | *Weight Percentage, %* | |
|---|---|---|---|
| | | *OG2301 Catalyzed Gasoline-Powered Vehicle Start Exhaust (E6 Summer)* | *OG2302 Catalyzed Gasoline-Powered Vehicle Start Exhaust (E6 Winter)* |
| 1-methyl-4-n-propylbenzene | 98182 | 0.003781 | 0.044681 |
| 1-methylcyclopentene | 92000 | 0.001092 | 0.146453 |
| 1-nonene | 43267 | 0.040463 | 0.042031 |
| 1-octene | 43265 | 0.063034 | 0.013233 |
| 1-pentene | 43224 | 0.146317 | 0.175609 |
| 1-propyne | 43209 | 0.017558 | 0.070632 |
| 2,2,3-trimethylbutane | 43160 | 0.039696 | 0.003965 |
| 2,2,4-trimethylheptane | 98174 | 0.037342 | 0.049033 |
| 2,2,4-trimethylhexane | 45222 | 0.048410 | 0.020902 |
| 2,2,4-trimethylpentane | 43276 | 4.296141 | 2.075336 |
| 2,2,5-trimethylheptane | 43252 | 0.214932 | 0.141610 |
| 2,2,5-trimethylhexane | 98033 | 0.675574 | 0.368097 |
| 2,2-dimethylbutane | 43291 | 0.298101 | 0.358723 |
| 2,2-dimethylhexane | 98138 | 0.012068 | 0.051277 |
| 2,2-dimethyloctane | 98175 | 0.075335 | 0.051919 |
| 2,2-dimethylpentane | 90042 | 0.006405 | 0.054377 |
| 2,2-dimethylpropane | 98130 | 0.001320 | 0.001997 |
| 2,3,3-trimethylpentane | 43280 | 0.001789 | 0.046850 |
| 2,3,4-trimethylpentane | 43279 | 1.457128 | 0.831796 |
| 2,3,5-trimethylhexane | 98141 | 0.079541 | 0.080762 |
| 2,3-dihydroindene (indan) | 98044 | 0.183994 | 0.210934 |
| 2,3-dimethyl-1-butene | 43234 | 0.004053 | 0.032921 |
| 2,3-dimethyl-2-pentene | 90061 | 0.006982 | 0.024785 |
| 2,3-dimethylbutane | 98001 | 0.828650 | 0.600380 |
| 2,3-dimethylheptane | 98145 | 0.009483 | 0.017128 |
| 2,3-dimethylhexane | 98139 | 0.476855 | 0.295937 |
| 2,3-dimethyloctane | 98183 | 0.073742 | 0.038564 |
| 2,3-dimethylpentane | 43274 | 1.554008 | 1.333478 |
| 2,4,4-trimethyl-1-pentene | 98054 | 0.003857 | 0.034870 |
| 2,4,4-trimethyl-2-pentene | 98055 | 0.032287 | 0.003099 |
| 2,4,4-trimethylhexane | 45223 | 0.028176 | 0.046543 |
| 2,4-dimethyl-1-pentene | 90063 | 0.003011 | 0.003065 |
| 2,4-dimethyl-2-pentene | 90062 | 0.004391 | 0.001204 |
| 2,4-dimethylheptane | 98142 | 0.113238 | 0.066066 |
| 2,4-dimethylhexane | 43277 | 0.716445 | 0.516195 |
| 2,4-dimethyloctane | 98149 | 0.085046 | 0.057147 |
| 2,4-dimethylpentane | 43271 | 0.970185 | 0.677485 |
| 2,5-dimethylhexane | 43278 | 0.701497 | 0.487418 |
| 2,5-dimethyloctane | 98176 | 0.075224 | 0.065886 |
| 2,6-dimethylheptane | 98157 | 0.156461 | 0.118913 |
| 2,6-dimethyloctane | 98177 | 0.037706 | 0.030804 |
| 2-methyl-1,3-butadiene | 43243 | 0.125220 | 0.113470 |
| 2-methyl-1-butene | 43225 | 0.307814 | 0.250884 |
| 2-methyl-1-pentene | 98040 | 0.054727 | 0.056415 |
| 2-methyl-2-butene | 43228 | 0.416337 | 0.340760 |
| 2-methyl-2-hexene | 90028 | 0.028763 | 0.009976 |
| 2-methyl-2-pentene | 98004 | 0.124452 | 0.127171 |
| 2-methylbutane | 98132 | 3.551859 | 3.412237 |

| *Species Name* | *SAROAD* | *Weight Percentage, %* | |
|---|---|---|---|
| | | *OG2301 Catalyzed Gasoline-Powered Vehicle Start Exhaust (E6 Summer)* | *OG2302 Catalyzed Gasoline-Powered Vehicle Start Exhaust (E6 Winter)* |
| 2-methylheptane | 98140 | 0.511690 | 0.580107 |
| 2-methylhexane | 43275 | 1.056571 | 1.114728 |
| 2-methylindan | 91108 | 0.076360 | 0.096097 |
| 2-methylnonane | 90047 | 0.358978 | 0.332334 |
| 2-methylpentane | 43229 | 2.055310 | 2.052084 |
| 2-methylpropene | 43215 | 1.908143 | 1.204810 |
| 2-methyl-trans-3-hexene | 91006 | 0.020070 | 0.006799 |
| 3,3-dimethyl-1-butene | 98169 | 0.028468 | 0.012678 |
| 3,3-dimethylhexane | 98171 | 0.025366 | 0.010837 |
| 3,3-dimethyloctane | 98184 | 0.067675 | 0.072333 |
| 3,3-dimethylpentane | 90040 | 0.114339 | 0.091570 |
| 3,4-dimethyl-1-pentene | 90075 | 0.005281 | 0.006181 |
| 3,4-dimethylhexane | 98150 | 0.127653 | 0.114000 |
| 3,5-dimethylheptane | 98144 | 0.177986 | 0.191733 |
| 3-ethyl-2-pentene | 98007 | 0.007490 | 0.004442 |
| 3-ethylpentane | 43300 | 0.091290 | 0.086924 |
| 3-methyl-1-butene | 43223 | 0.117435 | 0.086659 |
| 3-methyl-1-hexene | 90030 | 0.000799 | 0.001431 |
| 3-methyl-1-pentene | 43211 | 0.054793 | 0.036422 |
| 3-methyl-cis-2-hexene | 90029 | 0.016181 | 0.002608 |
| 3-methyl-cis-2-pentene | 98163 | 0.057995 | 0.065937 |
| 3-methylcyclopentene | 43272 | 0.061340 | 0.047265 |
| 3-methylheptane | 43298 | 0.574003 | 0.674444 |
| 3-methylhexane | 43295 | 1.115241 | 1.184676 |
| 3-methyloctane | 98172 | 0.270559 | 0.316217 |
| 3-methylpentane | 43230 | 1.280880 | 1.297075 |
| 3-methyl-trans-2-pentene | 43270 | 0.042809 | 0.030619 |
| 3-methyl-trans-3-hexene | 90032 | 0.009054 | 0.004576 |
| 4-methyl-1-pentene | 98135 | 0.001943 | 0.033780 |
| 4-methylheptane | 43297 | 0.182920 | 0.209190 |
| 4-methylindan | 91107 | 0.012046 | 0.020125 |
| 4-methyloctane | 98173 | 0.395437 | 0.439479 |
| 4-methyl-trans-2-hexene | 90031 | 0.017836 | 0.008610 |
| 4-methyl-trans-2-pentene | 43293 | 0.078615 | 0.052163 |
| 5-methylindan | 91106 | 0.065762 | 0.086908 |
| acetaldehyde | 43503 | 0.951349 | 1.275166 |
| acetone (2-propanone) | 43551 | 0.330498 | 0.388951 |
| acrolein (propenal) | 43505 | 0.006929 | 0.004070 |
| benzaldehyde | 45501 | 0.217376 | 0.292173 |
| benzene | 45201 | 2.835520 | 2.472889 |
| butyraldehyde (butanal) | 43510 | 0.033725 | 0.091580 |
| cis-1,2-dimethylcyclohexane | 91055 | 0.071466 | 0.064237 |
| cis-1,3-dimethylcyclohexane | 98180 | 0.257902 | 0.272220 |
| cis-1,3-dimethylcyclopentane | 91018 | 0.318122 | 0.351731 |
| cis-1-methyl-3-ethylcyclopentane | 90080 | 0.104866 | 0.115387 |
| cis-2-butene | 43217 | 0.323769 | 0.285669 |
| cis-2-heptene | 91028 | 0.037283 | 0.013929 |
| cis-2-hexene | 98035 | 0.007550 | 0.038691 |

| *Species Name* | *SAROAD* | *Weight Percentage, %* | |
|---|---|---|---|
| | | *OG2301 Catalyzed Gasoline-Powered Vehicle Start Exhaust (E6 Summer)* | *OG2302 Catalyzed Gasoline-Powered Vehicle Start Exhaust (E6 Winter)* |
| cis-2-octene | 43266 | 0.013735 | 0.001060 |
| cis-2-pentene | 43227 | 0.144155 | 0.158512 |
| cis-3-hexene | 98003 | 0.000799 | 0.006824 |
| crotonaldehyde | 98156 | 0.102024 | 0.141192 |
| cyclohexane | 43248 | 0.607256 | 0.683235 |
| cyclohexene | 43273 | 0.045857 | 0.054053 |
| cyclopentane | 43242 | 0.201746 | 0.219907 |
| cyclopentene | 43292 | 0.148202 | 0.113865 |
| ethane | 43202 | 1.562321 | 1.090819 |
| ethanol | 43302 | 1.427873 | 1.196625 |
| ethene | 43203 | 8.132314 | 8.146528 |
| ethylbenzene | 45203 | 1.417089 | 1.463958 |
| ethylcyclohexane | 43288 | 0.109312 | 0.116524 |
| ethylcyclopentane | 98057 | 0.033697 | 0.001168 |
| ethyne | 43206 | 3.631952 | 3.702233 |
| formaldehyde | 43502 | 1.541993 | 1.834332 |
| hexanal | 98159 | 0.079838 | 0.048667 |
| methacrolein | 43506 | 0.067429 | 0.044645 |
| methane | 43201 | 6.772481 | 10.414614 |
| methanol | 43301 | | 0.067184 |
| methylcyclohexane | 43261 | 0.776712 | 0.738456 |
| methylcyclopentane | 43262 | 1.439598 | 1.580386 |
| methylethylketone | 43552 | 0.083883 | 0.126155 |
| methylpropane | 43214 | 0.053451 | 0.369197 |
| methyl-tert-butyl-ether | 43378 | 0.049519 | 0.014658 |
| m-tolualdehyde | 45502 | 0.086408 | 0.084306 |
| m-xylene | 45205 | 3.530378 | 3.611055 |
| naphthalene | 98046 | 0.063994 | 0.026462 |
| n-butane | 43212 | 0.422002 | 1.838861 |
| n-decane | 43238 | 0.226963 | 0.138895 |
| n-dodecane | 43255 | 0.108532 | 0.014520 |
| n-heptane | 43232 | 0.697704 | 0.799063 |
| n-hexane | 43231 | 1.044985 | 1.237502 |
| n-nonane | 43235 | 0.242230 | 0.256629 |
| n-octane | 43233 | 0.367226 | 0.417043 |
| n-pentane | 43220 | 1.273893 | 1.433924 |
| n-pentylbenzene | 45255 | 0.012699 | 0.021803 |
| n-propylbenzene | 45209 | 0.285716 | 0.319829 |
| n-undecane (hendecane) | 43241 | 0.111498 | 0.061037 |
| o-xylene | 45204 | 1.953450 | 1.951193 |
| propane | 43204 | 0.080814 | 0.127862 |
| propene | 43205 | 4.787746 | 3.942810 |
| propionaldehyde (propanal) | 43504 | 0.109996 | 0.159442 |
| p-xylene | 45206 | 1.766653 | 1.805014 |
| styrene | 45220 | 0.282979 | 0.283079 |
| toluene | 45202 | 8.025091 | 7.495735 |
| trans-1,2-dimethylcyclopentane | 91021 | 0.260478 | 0.308809 |
| trans-1,3-dimethylcyclohexane | 98059 | 0.150750 | 0.158954 |

| *Species Name* | *SAROAD* | *Weight Percentage, %* | |
|---|---|---|---|
| | | *OG2301 Catalyzed Gasoline-Powered Vehicle Start Exhaust (E6 Summer)* | *OG2302 Catalyzed Gasoline-Powered Vehicle Start Exhaust (E6 Winter)* |
| trans-1,3-dimethylcyclopentane | 91019 | 0.338556 | 0.374234 |
| trans-1,3-pentadiene | 90100 | 0.018921 | 0.026548 |
| trans-1,4-dimethylcyclohexane | 98181 | 0.099721 | 0.096305 |
| trans-1-methyl-3-ethylcyclopentane | 91044 | 0.125158 | 0.132920 |
| trans-2-butene | 43216 | 0.434688 | 0.379370 |
| trans-2-heptene | 91026 | 0.024531 | 0.029815 |
| trans-2-hexene | 98034 | 0.099295 | 0.104896 |
| trans-2-octene | 43263 | 0.041412 | 0.043108 |
| trans-2-pentene | 43226 | 0.267402 | 0.266926 |
| trans-3-heptene | 98006 | 0.042040 | 0.040558 |
| trans-3-hexene | 98136 | 0.057795 | 0.061369 |
| trans-4-octene | 43250 | 0.018411 | 0.026974 |
| valeraldehyde | 98200 | 0.024231 | 0.021001 |
| *Total* | | *100.000000* | *100.000000* |

**Appendix 2. EICs/SCCs to be associated with catalyzed gasoline-powered vehicle start exhaust speciation profiles**

| *EIC/SCC* | *Names* | | |
|---|---|---|---|
| 2 | EMFAC/DTIM | CATALYST START EXHAUST | GASOLINE, ALL VEHICLES |
| 202 | EMFAC/DTIM | CATALYST START EXHAUST | GASOLINE, LMV |
| 302 | EMFAC/DTIM | CATALYST START EXHAUST | GASOLINE, HDV |
| 43075 | ON-ROAD VEHICLES | LIGHT DUTY PASSENGER | COLD START |
| 46920 | ON-ROAD VEHICLES | LIGHT DUTY TRUCKS | COLD START |
| 82339 | ON-ROAD VEHICLES | LIGHT DUTY PASSENGER | CATALYST COLD START |
| 82362 | ON-ROAD VEHICLES | LIGHT/MEDIUM TRUCKS | CATALYST COLD START |
| 82446 | ON-ROAD VEHICLES | LIGHT DUTY PASSENGER | CATALYST HOT START |
| 82479 | ON-ROAD VEHICLES | LIGHT/MEDIUM TRUCKS | CATALYST HOT START |
| 84020 | ON-ROAD VEHICLES | LIGHT DUTY PASSENGER | CATALYST STARTS |
| 84152 | ON-ROAD VEHICLES | LT. DUTY TRUCKS - 1 | CATALYST STARTS |
| 84368 | ON-ROAD VEHICLES | MEDIUM TRUCKS | CATALYST STARTS |
| 86223 | ON-ROAD VEHICLES | LT. DUTY TRUCKS - 2 | CATALYST STARTS |
| 86413 | ON-ROAD VEHICLES | LT.HVY.DTY TRUCKS- 1 | CATALYST STARTS |
| 86538 | ON-ROAD VEHICLES | LT.HVY.DTY TRUCKS- 2 | CATALYST STARTS |
| 86645 | ON-ROAD VEHICLES | MEDIUM HEAVY DUTY GAS | CATALYST STARTS |
| 86769 | ON-ROAD VEHICLES | HEAVY HEAVY DUTY GAS | CATALYST STARTS |
| 86967 | ON-ROAD VEHICLES | MOTORCYCLES (MCY) | CATALYST STARTS |
| 87148 | ON-ROAD VEHICLES | HEAVY DUTY GAS URBAN | CATALYST STARTS |
| 87312 | ON-ROAD VEHICLES | SCHOOL BUSES (SB) | CATALYST STARTS |
| 87528 | ON-ROAD VEHICLES | MOTOR HOMES (MH) | CATALYST STARTS |
| 71073011000000 | ON-ROAD VEHICLES | LIGHT DUTY PASSENGER | CATALYST COLD START |
| 71073111000000 | ON-ROAD VEHICLES | LIGHT DUTY PASSENGER | CATALYST STARTS |
| 71073211000000 | ON-ROAD VEHICLES | LIGHT DUTY PASSENGER | CATALYST HOT START |
| 72073011000000 | ON-ROAD VEHICLES | LIGHT/MEDIUM TRUCKS | CATALYST COLD START |
| 72073211000000 | ON-ROAD VEHICLES | LIGHT/MEDIUM TRUCKS | CATALYST HOT START |
| 72273111000000 | ON-ROAD VEHICLES | LT. DUTY TRUCKS – 1 | CATALYST STARTS |
| 72373111000000 | ON-ROAD VEHICLES | LT. DUTY TRUCKS – 2 | CATALYST STARTS |
| 72473111000000 | ON-ROAD VEHICLES | MEDIUM TRUCKS | CATALYST STARTS |
| 73273111000000 | ON-ROAD VEHICLES | LT.HVY.DTY TRUCKS- 1 | CATALYST STARTS |
| 73373111000000 | ON-ROAD VEHICLES | LT.HVY.DTY TRUCKS- 2 | CATALYST STARTS |
| 73473111000000 | ON-ROAD VEHICLES | MED. HVY. DTY TRUCKS | CATALYST STARTS |
| 73673111000000 | ON-ROAD VEHICLES | HVY. HVY. DTY TRUCKS | CATALYST STARTS |
| 75073111000000 | ON-ROAD VEHICLES | MOTORCYCLES (MCY) | CATALYST STARTS |
| 76273111000000 | ON-ROAD VEHICLES | HVY. GAS URBAN BUSES | CATALYST STARTS |
| 77073111000000 | ON-ROAD VEHICLES | SCHOOL BUSES (SB) | CATALYST STARTS |
| 77173111000000 | ON-ROAD VEHICLES | SCHOOL BUSES GAS | CATALYST STARTS |
| 77673111000000 | ON-ROAD VEHICLES | OTHER BUSES | CATALYST STARTS |
| 77773111000000 | ON-ROAD VEHICLES | OTHER BUSES GAS | CATALYST STARTS |
| 78073111000000 | ON-ROAD VEHICLES | MOTOR HOMES (MH) | CATALYST STARTS |