

**Assessing the Effect of Five Gasoline Properties on Exhaust Emissions from Light-Duty Vehicles certified to Tier-2 Standards
(EPAct/V2/E-89: Phase 3)**

Part II: Data Analysis and Model Development

APPENDIX E

Preliminary Reduced Models

Development of the models presented below is described in Section 5.3 of the report. All models are based on the 16-parameter full model, as shown in Equation 1. All terms were included at the outset of model fitting, with the exception of T90×T90. Using the notation for standardized predictors, also shown in Equation 2, the model is also expressed in Equation 2. Table E.1 summarizes the model-fitting approaches applied to each bag for each emission. Table E.2 through E.7 present the coefficients for interim reduced models for THC, NMOG, CH₄, CO, NO_x and PM, respectively.

$$\begin{aligned} \ln Y = & \beta_0 + \\ & \beta_1 \cdot \text{etOH} + \beta_2 \cdot \text{Arom} + \beta_3 \cdot \text{RVP} + \beta_4 \cdot \text{T50} + \beta_5 \cdot \text{T90} + \\ & \beta_6 \cdot \text{T50}^2 + \beta_7 \cdot \text{etOH}^2 \\ & \beta_8 \cdot \text{etOH} \times \text{Arom} + \beta_9 \cdot \text{etOH} \times \text{RVP} + \beta_{10} \cdot \text{etOH} \times \text{T50} + \beta_{11} \cdot \text{etOH} \times \text{T90} + \\ & \beta_{12} \cdot \text{Arom} \times \text{T50} + \beta_{13} \cdot \text{Arom} \times \text{T90} + \beta_{14} \cdot \text{T50} \times \text{T90} + \beta_{15} \cdot \text{Arom} \times \text{RVP} + \beta_{16} \cdot \text{RVP} \times \text{T90} + \\ & \varepsilon \end{aligned} \quad \begin{array}{l} \text{Equation} \\ 1 \end{array}$$

$$\begin{aligned} \ln Y = & \beta_0 + \\ & \beta_1 Z_e + \beta_2 Z_a + \beta_3 Z_r + \beta_4 Z_5 + \beta_5 Z_9 + \\ & \beta_6 ZZ_{55} + \beta_7 ZZ_{ee} \\ & \beta_8 ZZ_{ea} + \beta_9 ZZ_{er} + \beta_{10} ZZ_{e5} + \beta_{11} ZZ_{e9} + \\ & \beta_{12} ZZ_{a5} + \beta_{13} ZZ_{a9} + \beta_{14} ZZ_{59} + \beta_{15} ZZ_{ar} + \beta_{16} ZZ_{r9} + \\ & \varepsilon \end{aligned} \quad \begin{array}{l} \text{Equation 2} \end{array}$$

Table E.1. Design and Modeling Parameters for Best-fit models, by Compound and Bag.

Compound	Bag	n_{removed}	Model Type	Selection Method
THC	1	0	Mixed	Minimize BIC
	2	0	Mixed	Minimize BIC
	3	0	Mixed	Minimize BIC
CO	1	0	Mixed	Minimize BIC
	2	0	Mixed	Minimize BIC
	3	0	Mixed	Minimize BIC
NO _x	1	0	Mixed	Minimize BIC
	2	0	Mixed	Minimize BIC
	3	0	Tobit	Backwards elimination
PM	1	2	Tobit	Backwards elimination
	2	1	Tobit	Backwards elimination
	3	1	Tobit	Backwards elimination
NMOG	1	0	Mixed	Minimize BIC
	2	0	Tobit	Backwards elimination
	3	0	Tobit	Backwards elimination
CH ₄	1	0	Mixed	Backwards elimination
	2	0	Mixed	Backwards elimination
	3	0	Mixed	Backwards elimination

Table E.2. THC: Reduced Models, starting from 16-term full model.

Model term	Notation	Bag 1	Bag 2	Bag 3
Intercept	Intercept	-0.8658	-4.9092	-4.2300
etOH	Z_e	0.06793	0.06814	0.007879
Arom	Z_a	0.08343	-0.02281	-0.06120
RVP	Z_r	-0.04669		-0.01423
T50	Z_5	0.1490	-0.03953	0.03595
T90	Z_9	0.01435	0.07154	0.04904
etOH \times etOH	ZZ_{ee}	0.04065	0.06681	
T50 \times T50	ZZ_{55}	0.07555		
etOH \times Arom	ZZ_{ea}	0.02297	0.03054	
etOH \times RVP	ZZ_{er}			0.01666
etOH \times T50	ZZ_{e5}	0.03426	0.04028	-0.03125
etOH \times T90	ZZ_{e9}	0.04782		
Arom \times RVP	ZZ_{ar}			
Arom \times T50	ZZ_{a5}		0.03386	
Arom \times T90	ZZ_{a9}	0.02264		
T50 \times T90	ZZ_{59}		0.02886	
RVP \times T90	ZZ_{r9}			

Table E.3. NMOG: Reduced Models, starting from 16-term full model.

Model term	Notation	Bag 1	Bag 2	Bag 3
Intercept	Intercept	0.9513	-5.5166 ¹	-5.8449 ¹
etOH	Z_e	0.09272	0.0730	0.0339
Arom	Z_a	0.1051	0.0355	
RVP	Z_r	-0.04834	-0.0463	-0.0572
T50	Z_5	0.1541	0.0859	0.0783
T90	Z_9	0.01124	0.1091	0.1467
etOH \times etOH	ZZ_{ee}	0.04204	-0.0424	
T50 \times T50	ZZ_{55}	0.07866	0.0412	
etOH \times Arom	ZZ_{ea}	0.02171	0.0718	
etOH \times RVP	ZZ_{er}		-0.0313	0.0707
etOH \times T50	ZZ_{e5}	0.03576		-0.0728
etOH \times T90	ZZ_{e9}	0.04763		
Arom \times RVP	ZZ_{ar}	0.02724		
Arom \times T50	ZZ_{a5}		0.0738	
Arom \times T90	ZZ_{a9}	0.02049	0.0327	
T50 \times T90	ZZ_{59}	0.05437	0.0293	
RVP \times T90	ZZ_{r9}			

¹ Not fit by Tobit model; calculated manually from intercepts for individual vehicles.

Table E.4. CH₄: Reduced Models, starting from 16-term full model.

Model term	Notation	Bag 1	Bag 2	Bag 3
Intercept	Intercept	-3.0068	-5.7076	-4.5979
etOH	Z_e	0.08877	0.06076	0.03187
Arom	Z_a	-0.09816	-0.09211	-0.1004
RVP	Z_r	-0.02455	-0.02082	
T50	Z_5	0.1059	0.04477	0.01886
T90	Z_9	0.008573	0.02445	0.01856
etOH \times etOH	ZZ_{ee}	0.03133		
T50 \times T50	ZZ_{55}	0.05882	0.01398	
etOH \times Arom	ZZ_{ea}	0.03977	0.01047	
etOH \times RVP	ZZ_{er}			
etOH \times T50	ZZ_{e5}	0.02883		-0.02007
etOH \times T90	ZZ_{e9}	0.02655		
Arom \times RVP	ZZ_{ar}	0.02791		
Arom \times T50	ZZ_{a5}	0.02585		
Arom \times T90	ZZ_{a9}	0.03072		
T50 \times T90	ZZ_{59}	0.0228	0.01374	
RVP \times T90	ZZ_{r9}		-0.00992	

Table E.5. CO: Reduced Models, starting from 16-term full model.

Model term	Notation	Bag 1	Bag 2	Bag 3
Intercept	Intercept	1.3472	-1.3896	-1.1409
etOH	Z_e	-0.06967		-0.08154
Arom	Z_a	-0.01156	0.09798	0.07191
RVP	Z_r	0.02063	0.02838	0.02393
T50	Z_5	0.02159	0.02486	
T90	Z_9	-0.1469	0.04180	0.05781
etOH \times etOH	ZZ_{ee}	0.08535		
T50 \times T50	ZZ_{55}	0.07222		
etOH \times Arom	ZZ_{ea}	0.06244		
etOH \times RVP	ZZ_{er}			
etOH \times T50	ZZ_{e5}	0.1117		
etOH \times T90	ZZ_{e9}			
Arom \times RVP	ZZ_{ar}			
Arom \times T50	ZZ_{a5}			
Arom \times T90	ZZ_{a9}	0.03861		
T50 \times T90	ZZ_{59}		0.02177	
RVP \times T90	ZZ_{r9}			

Table E.6. NOx: Reduced Models, starting from 16-term full model.

Model term	Notation	Bag 1	Bag 2	Bag 3
Intercept	Intercept	-3.01636	-4.7882	-5.2554
etOH	Z_e	0.03802	0.04112	0.0884
Arom	Z_a	0.1336	0.03534	0.0667
RVP	Z_r	-0.01418	-0.01464	0.169
T50	Z_5	0.01026		-0.0224
T90	Z_9	0.02389	-0.0004567	0.085
etOH \times etOH	ZZ_{ee}	-0.05980		
T50 \times T50	ZZ_{55}	-0.05701		
etOH \times Arom	ZZ_{ea}	-0.03038	0.02739	
etOH \times RVP	ZZ_{er}			
etOH \times T50	ZZ_{e5}	-0.9774		0.0637
etOH \times T90	ZZ_{e9}	0.02544		
Arom \times RVP	ZZ_{ar}			
Arom \times T50	ZZ_{a5}			0.0894
Arom \times T90	ZZ_{a9}	-0.04769		
T50 \times T90	ZZ_{59}			
RVP \times T90	ZZ_{r9}	0.04562	-0.04014	

Table E.7. PM: Reduced models, starting from 16-term full model.

Model term	Notation	Bag 1	Bag 2	Bag 3
Intercept				
etOH	Z_e	0.1640	0.1158	-0.02120
Arom	Z_a	0.3795	0.1988	0.01860
RVP	Z_r			-0.1275
T50	Z_5	0.06650	-0.00370	-0.04110
T90	Z_9	0.2882	0.09530	
etOH \times etOH	ZZ_{ee}			
T50 \times T50	ZZ_{55}	0.08560		
etOH \times Arom	ZZ_{ea}			0.08490
etOH \times RVP	ZZ_{er}			
etOH \times T50	ZZ_{e5}			-0.08240
etOH \times T90	ZZ_{e9}			
Arom \times RVP	ZZ_{ar}			-0.1062
Arom \times T50	ZZ_{a5}			
Arom \times T90	ZZ_{a9}			
T50 \times T90	ZZ_{59}		0.1059	
RVP \times T90	ZZ_{r9}			