

# **Assessing the Effect of Five Gasoline Properties on Exhaust Emissions from Light-Duty Vehicles certified to Tier-2 Standards**

## **Analysis of Data from EPA Phase 3**

**(EPAct/V2/E-89)**

### **Appendix J.5**

#### **Final Model Fitting**

#### **Particulate Matter (PM) (Bag 2)**

No. Observations:	906
No. Vehicles:	15
No. censored measurements:	47
No. missing measurements:	2
No. measurements removed:	1
Model Type:	Tobit regression

### J.5.1 Model Fitting based on the 11-term design model.

Models fit for PM (Bag 2): (Grand Intercept not fit by Tobit models).

Model Term	Notation	Model						
		Full	FM3 <sup>1</sup>	FM4	FM5	FM6	FM7	FM8
etOH	$Z_e$	•	•	•	•	•	•	•
Arom	$Z_a$	•	•	•	•	•	•	•
RVP	$Z_r$	•	•	•	×			
T50	$Z_5$	•	•	•	•	•	×	
T90	$Z_9$	•	•	•	•	•	•	•
etOH × etOH	$ZZ_{ee}$	•	•	•	•	•	•	×
T50 × T50	$ZZ_{55}$	•	×					
etOH × Arom	$ZZ_{ea}$	•	×					
etOH × RVP	$ZZ_{er}$	•	•	×				
etOH × T50	$ZZ_{e5}$	•	•	•	•			
etOH × T90	$ZZ_{e9}$	•	×					

PM (Bag 2): Model fitting history, starting with the 11-term design model.

Fit Parameters			Test with respect to Previous Model		
Model	$p-1^1$	$-2\ln L$	Dev.	$d$	$\Pr > \chi^2$
Full Model	11	2954.321			
FM3	8	2954.834	0.513	3	0.916
FM4	7	2955.471	0.637	1	0.425
FM5	6	2957.466	1.995	1	0.158
FM6	5	2959.590	2.124	1	0.145
FM7	4	2959.643	0.053	1	0.818
FM8	3	2961.414	1.771	1	0.183

<sup>1</sup> Total number of terms excludes the intercept, as the Tobit models do not fit intercepts.

<sup>2</sup> Best fit with respect to the 17-term extended model.

**PM (Bag 2): Coefficients and Tests of Effect for the Full and Reduced Models, with respect to the 11-term design model.**

Effect	<i>Full Model</i>					<i>Reduced Model (FM8)</i>				
	Estimate	Std. Err.	d.f.	$\chi^2$ - value	$\text{Pr} > \chi^2$	Estimate	Std. Err.	d.f.	$\chi^2$ - value	$\text{Pr} > \chi^2$
Intercept <sup>1</sup>						-1.3107				
$Z_e$	0.0390	0.0552	1	0.500	0.48	0.1126	0.0370	1	9.27	0.0023
$Z_a$	0.1619	0.0384	1	17.8	<.0001	0.1662	0.0376	1	19.6	<.0001
$Z_r$	-0.0615	0.0438	1	1.97	0.16					
$Z_5$	-0.0725	0.0553	1	1.72	0.19					
$Z_9$	0.1064	0.0384	1	7.69	0.0055	0.1072	0.0376	1	8.14	0.0043
$ZZ_{ee}$	-0.1380	0.0739	1	3.48	0.062					
$ZZ_{55}$	-0.0143	0.0553	1	0.0700	0.80					
$ZZ_{ea}$	0.0210	0.0375	1	0.31	0.58					
$ZZ_{er}$	-0.0272	0.0383	1	0.50	0.48					
$ZZ_{e5}$	-0.1109	0.0795	1	1.95	0.16					
$ZZ_{e9}$	-0.0135	0.0377	1	0.13	0.72					
$\sigma_{\text{veh}}^2$ <sup>1</sup>						0.7827				
$\sigma_{\varepsilon}^2$	1.1294					1.1337				

<sup>1</sup> Not fit by Tobit model; calculated manually from individual vehicle intercepts.

## J.5.2 Model Fitting based on the 17-term extended model.

### Models fit for PM (Bag 2): (Grand Intercept not fit by Tobit models).

Model Term	Notation	Model									
		Full	FM4 <sup>1</sup>	FM5	FM6	FM7	FM8	FM9	FM10	FM11	FM12
etOH	$Z_e$	•	•	•	•	•	•	•	•	•	•
Arom	$Z_a$	•	•	•	•	•	•	•	•	•	•
RVP	$Z_r$	•	•	•	•	•	•	•	×		
T50	$Z_5$	•	•	•	•	•	•	•	•	•	•
T90	$Z_9$	•	•	•	•	•	•	•	•	•	•
etOH × etOH	$ZZ_{ee}$	•	•	•	•	•	•	•	•	•	×
T50 × T50	$ZZ_{55}$	•	×								
etOH × Arom	$ZZ_{ea}$	•	×								
etOH × RVP	$ZZ_{er}$	•	×								
etOH × T50	$ZZ_{e5}$	•	•	•	•	•	•	•	•	×	
etOH × T90	$ZZ_{e9}$	•	•	•	•	•	•	×			
T90 × T90	$ZZ_{99}$	•	•	•	•	•	×				
Arom × RVP	$ZZ_{ar}$	•	•	•	×						
Arom × T50	$ZZ_{a5}$	•	•	•	•	×					
Arom × T90	$ZZ_{a9}$	•	•	×							
T50 × T90	$ZZ_{59}$	•	•	•	•	•	•	•	•	•	•
RVP × T90	$ZZ_{r9}$	•	×								

<sup>1</sup> Indicates “Full minus 3,” etc.

### PM (Bag 2): Model fitting history, starting with the 17-term extended model.

Fit Parameters			Test with respect to Previous Model		
Model	$p-I^1$	$-2\ln L$	Dev.	$d$	$\Pr > \chi^2$
Full Model	17	2937.842			
FM4	13	2938.618	0.776	4	0.9416
FM5	12	2939.112	0.494	1	0.4821
FM6	11	2941.062	1.950	1	0.1626
FM7	10	2943.444	2.382	1	0.1227
FM8	9	2945.255	1.811	1	0.1784
FM9	8	2947.232	1.977	1	0.1597
FM10	7	2949.896	2.664	1	0.1026
FM11	6	2952.334	2.438	1	0.1184
FM12 <sup>2</sup>	5	2954.483	2.149	1	0.1427

<sup>1</sup> Total number of terms excludes the intercept, as the Tobit Models do not fit intercepts.  
<sup>2</sup> Best fit with respect to the 17-term extended model.

**PM (Bag 2): Coefficients and Tests of Effect for the Full and Reduced Models, with respect to the 17-term extended model.**

Effect	<i>Full Model</i>					<i>Reduced Model (FM12)</i>				
	Estimate	Std. Err.	d.f.	$\chi^2$ - value	$\text{Pr}>\chi^2$	Estimate	Std. Err.	d.f.	$\chi^2$ - value	$\text{Pr}>\chi^2$
Intercept <sup>1</sup>										
$Z_e$	0.0019	0.0679	1	0.0000	0.98	0.1158	0.0450	1.0000	6.6300	0.0100
$Z_a$	0.2522	0.0461	1	30.0	<0.0001	0.1988	0.0398	1.0000	24.9000	<0.0001
$Z_r$	-0.1588	0.0630	1	6.35	0.012					
$Z_5$	-0.1865	0.0903	1	4.26	0.039	-0.0037	0.0463	1.0000	0.0100	0.9355
$Z_9$	0.1566	0.0494	1	10.1	0.0015	0.0953	0.0377	1.0000	6.3900	0.0115
$ZZ_{ee}$	-0.1590	0.0770	1	4.27	0.039					
$ZZ_{55}$	-0.0315	0.0629	1	0.25	0.62					
$ZZ_{ea}$	-0.0078	0.0625	1	0.020	0.90					
$ZZ_{er}$	-0.0249	0.0423	1	0.35	0.56					
$ZZ_{e5}$	-0.1421	0.0814	1	3.05	0.081					
$ZZ_{e9}$	0.1097	0.0515	1	4.53	0.033					
$ZZ_{ar}$	-0.1059	0.0788	1	1.81	0.18					
$ZZ_{a5}$	-0.1157	0.0849	1	1.86	0.17					
$ZZ_{a9}$	0.0346	0.0430	1	0.65	0.42					
$ZZ_{59}$	0.1600	0.0560	1	8.16	0.0043	0.1059	0.0402	1.0000	6.9500	0.0084
$ZZ_{r9}$	-0.0118	0.0487	1	0.060	0.81					
$\sigma_{\text{veh}}^2$ <sup>1</sup>										
$\sigma_{\varepsilon}^2$	1.1194					1.1295				

<sup>1</sup> Not fit by Tobit model.