

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 H.5

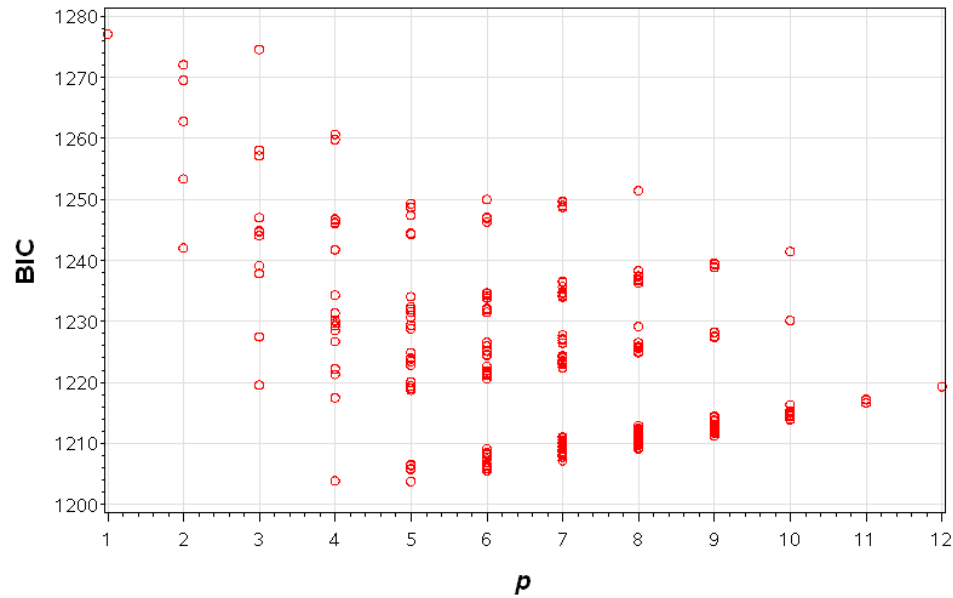
Final Model Fitting

Carbon Monoxide (CO) (Bag 3)

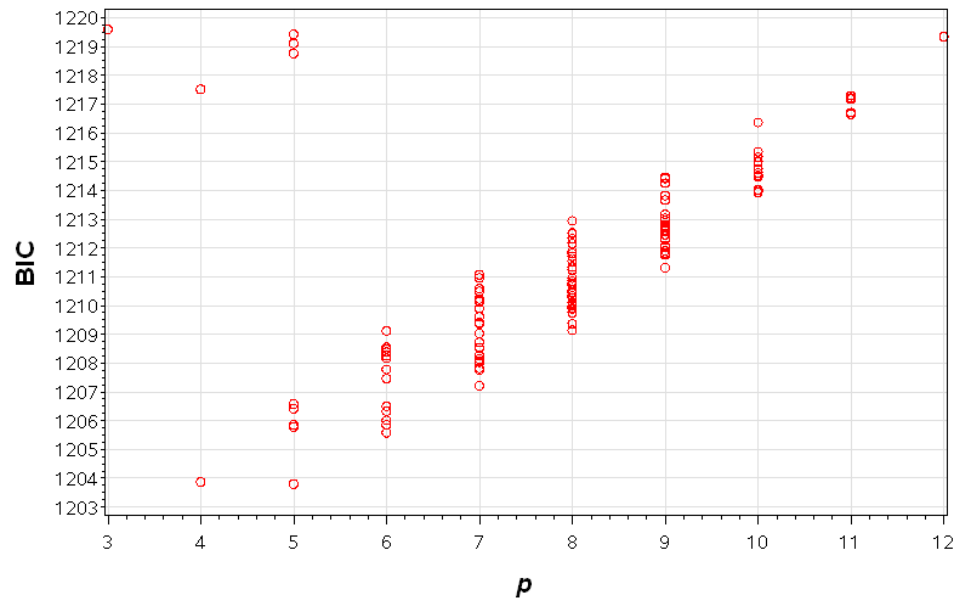
No. Observations:	956
No. Vehicles:	15
No. censored measurements:	0
No. missing measurements:	0
No. measurements removed:	0
Model Type:	Mixed model

H.5.1 Model fitting with respect to the 11-term design model.

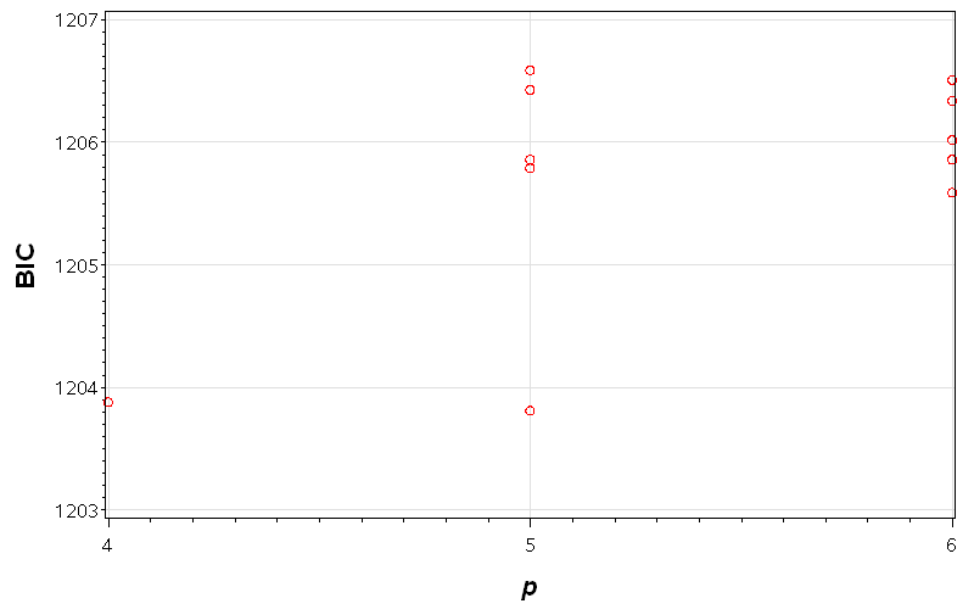
Design Model (11-terms): Bayesian Information Criterion (BIC) vs. number of terms in model (p) for all possible models respecting hierarchy.



Design Model (11-terms): Bayesian Information Criterion (BIC) vs. number of terms in model (p) for all possible models respecting hierarchy (CLOSEUP of previous figure).



Design Model (11-terms): Bayesian Information Criterion (BIC) vs. number of terms in model (p) for all possible models respecting hierarchy (CLOSEUP of previous figure).



CO (Bag 3): Number of terms (p), Goodness-of-fit (BIC) and terms included in the 35 best-fitting candidate models (out of a total of 294 possible models with hierarchy). (Terms included in models ranked 1-6 comprise the “superset” for final model-fitting).

Rank	p	BIC	Design Terms									
			etOH	Arom	RVP	T50	T90	etOH \times etOH	T50 \times T50	etOH \times Arom	etOH \times RVP	etOH \times T50
1	5	1203.81	•	•	•		•					
2	4	1203.88	•	•			•					
3	6	1205.59	•	•	•		•		•			
4	5	1205.79	•	•			•		•			
5	5	1205.86	•	•			•					•
6	6	1205.86	•	•	•	•	•					
7	6	1206.02	•	•	•		•					•
8	6	1206.34	•	•	•		•	•				
9	5	1206.43	•	•			•	•				
10	6	1206.51	•	•	•		•			•		
11	5	1206.59	•	•		•	•					
12	7	1207.22	•	•	•	•	•				•	
13	6	1207.47	•	•		•	•				•	
14	7	1207.77	•	•	•	•	•			•		
15	6	1207.79	•	•			•			•		•
16	7	1207.83	•	•	•		•			•		•
17	7	1208.04	•	•	•		•	•		•		
18	7	1208.08	•	•	•	•	•					•
19	7	1208.15	•	•	•	•	•					
20	6	1208.18	•	•		•	•		•			
21	6	1208.26	•	•			•	•		•		
22	7	1208.28	•	•	•	•	•	•				
23	7	1208.28	•	•	•		•			•	•	
24	6	1208.39	•	•			•	•				•
25	6	1208.5	•	•		•	•			•		
26	7	1208.54	•	•	•		•	•				•
27	7	1208.55	•	•	•	•	•				•	
28	6	1208.56	•	•		•	•					•
29	7	1208.73	•	•	•		•				•	•
30	7	1209.04	•	•	•		•	•			•	
31	6	1209.13	•	•		•	•	•				
32	8	1209.15	•	•	•	•	•			•		•
33	8	1209.37	•	•	•	•	•				•	•
34	7	1209.38	•	•		•	•				•	•
35	7	1209.42	•	•		•	•			•		

Models fit for CO (Bag 3): (all models include an intercept term).

Model Term	Notation	Model	
		Superset	SM3 ¹
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}	•	×

¹ Represents “Superset minus 3,” etc.

CO (Bag 3): Model fitting history, starting with the 8-term superset model.

Fit Parameters				<i>Test with respect to Previous Model</i>		
Model	p	$-2\ln L$	BIC ¹	Dev.	d	$\Pr > \chi^2$
Superset	8	1182.918	1209.999			
SM3 ²	5	1184.850	1203.806	1.931	3	0.587

¹ A lower value indicates a better fit.

² Best fit with respect to the 11-term design model.

CO (Bag 3): Coefficients and Tests of Effect for the Superset and Reduced Models, with respect to the 11-term design model.

Effect	<i>Full Model (superset)</i>				
	Estimate	Std. Err.	d.f.	t-value	Pr>t
Intercept	-1.1406	0.4035	15	-2.83	0.013
Z_{ε}	-0.0722	0.0182	941	-3.97	0.000
Z_{α}	0.0736	0.0142	941	5.17	0.000
Z_{γ}	0.0284	0.0158	941	1.79	0.073
Z_{β}	0.0141	0.0192	941	0.73	0.463
Z_{ϑ}	0.0586	0.0143	941	4.09	0.000
$ZZ_{\varepsilon\varepsilon}$	---	---	---	---	---
$ZZ_{\beta\beta}$	---	---	---	---	---
$ZZ_{\varepsilon\alpha}$	0.0123	0.0139	941	0.89	0.376
$ZZ_{\varepsilon\gamma}$	---	---	---	---	---
$ZZ_{\varepsilon\beta}$	---	---	---	---	---
$ZZ_{\varepsilon\vartheta}$	0.0096	0.0140	941	0.69	0.491

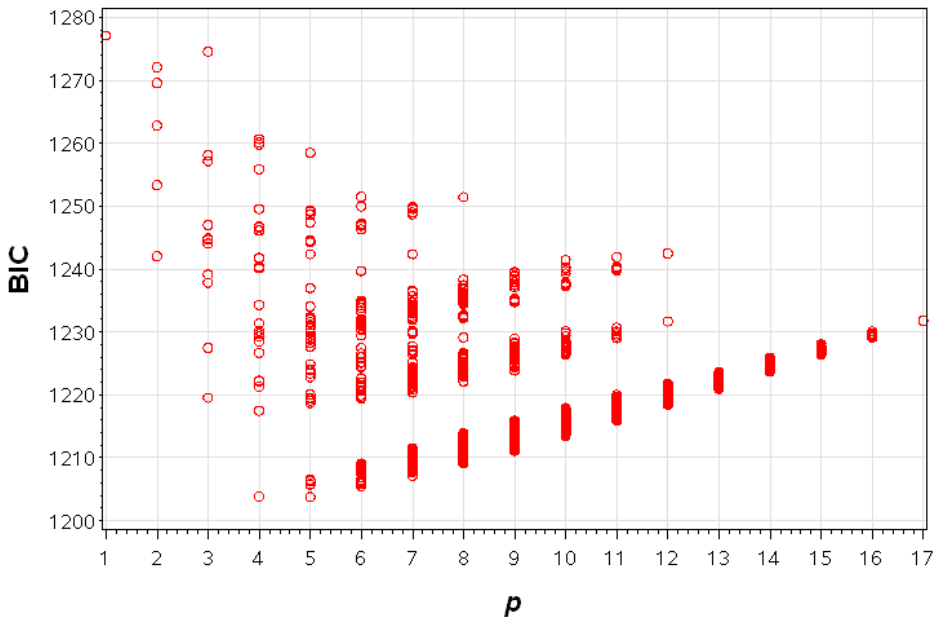
σ_{veh}^2	2.4396
σ_{τ}^2	0.1815

<i>Reduced Model (SM3)</i>				
Estimate	Std. Err.	d.f.	t-value	Pr>t
-1.1409	0.4037	15	-2.83	0.013
-0.0815	0.0140	941	-5.82	0.000
0.0719	0.0141	941	5.10	0.000
0.0239	0.0143	941	1.67	0.095
0.0578	0.0142	941	4.07	0.000
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---	---	---	---	---
---	---	---	---	---
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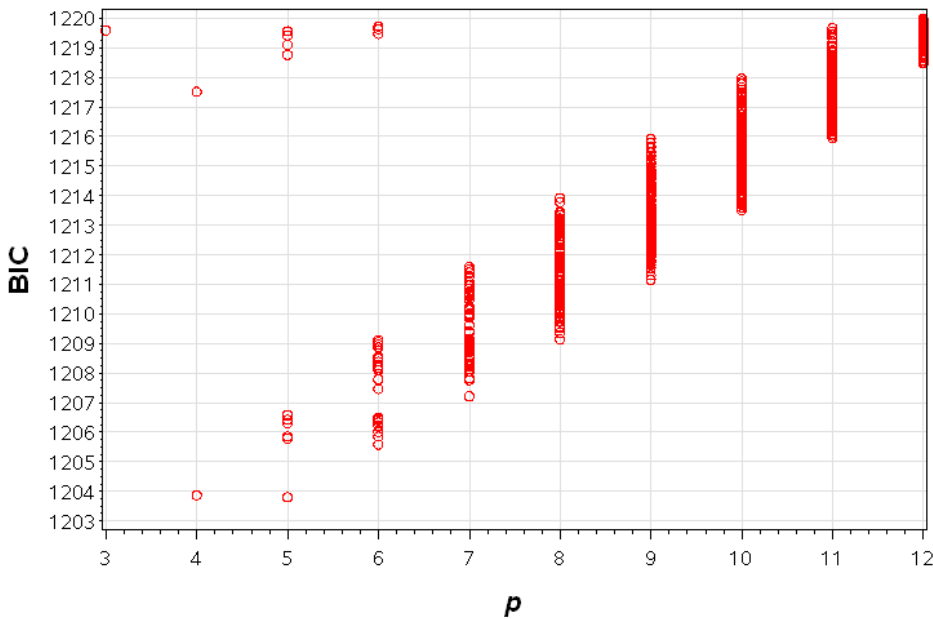
σ_{veh}^2	2.4412
σ_{τ}^2	0.1819

H.5.2 Model Fitting with respect to the 16-term extended Model.

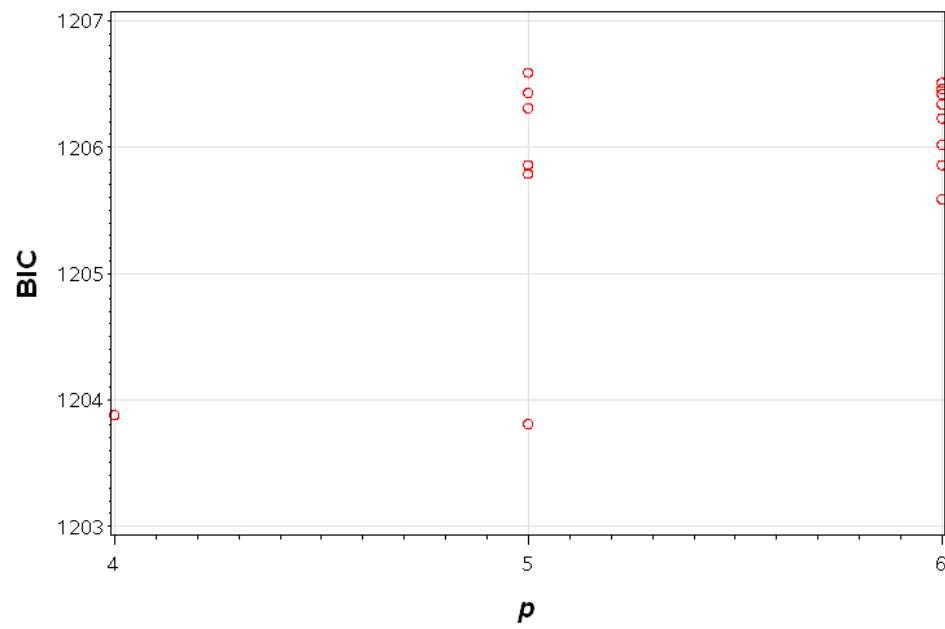
Extended Model (16-terms): Bayesian Information Criterion (BIC) vs. number of terms in model (p) for all possible models respecting hierarchy.



Extended Model (16-terms): Bayesian Information Criterion (BIC) vs. number of terms in model (p) for subset of models respecting hierarchy (CLOSEUP of previous figure).



Extended Model (16-terms): Bayesian Information Criterion (BIC) vs. number of terms in model (p) for subset of models respecting hierarchy (CLOSEUP of previous figure).



CO (Bag 3): Number of terms (p), Goodness-of-fit (BIC) and terms included in the 35 best-fitting candidate models (out of a total of 2,964 possible models with hierarchy). (Terms included in models ranked 1-6 comprise the “superset” for final model-fitting).

Rank	p	BIC	Design Terms										Extended Terms					
			etOH	Arom	RVP	T50	T90	etOH \times etOH	T50 \times T50	etOH \times Arom	etOH \times RVP	etOH \times T50	etOH \times T90	Arom \times RVP	Arom \times T50	Arom \times T90	T50 \times T90	RVP \times T90
1	5	1203.81	•	•	•		•											
2	4	1203.88	•	•			•											
3	6	1205.59	•	•	•		•			•								
4	5	1205.79	•	•			•			•								
5	5	1205.86	•	•			•								•			
6	6	1205.86	•	•	•	•	•											
7	6	1206.02	•	•	•		•								•			
8	6	1206.23	•	•	•		•										•	
9	5	1206.31	•	•			•											
10	6	1206.34	•	•	•		•	•										
11	6	1206.42	•	•	•		•								•			
12	5	1206.43	•	•			•	•										
13	6	1206.46	•	•	•		•									•		
14	6	1206.51	•	•	•		•				•							
15	5	1206.59	•	•		•	•											
16	7	1207.22	•	•	•	•	•						•					
17	6	1207.47	•	•		•	•						•					
18	7	1207.77	•	•	•	•	•			•								
19	6	1207.79	•	•			•			•					•			
20	7	1207.83	•	•	•		•			•					•			
21	7	1208.04	•	•	•		•	•		•								
22	7	1208.08	•	•	•	•	•								•			
23	6	1208.1	•	•		•	•									•		
24	6	1208.12	•	•			•								•			
25	7	1208.14	•	•	•		•			•							•	
26	7	1208.15	•	•	•	•	•			•								
27	6	1208.18	•	•		•	•			•								
28	6	1208.19	•	•			•			•							•	
29	7	1208.22	•	•	•	•	•									•		
30	7	1208.23	•	•	•		•			•						•		
31	6	1208.26	•	•			•	•		•								
32	7	1208.28	•	•	•	•	•	•										
33	7	1208.28	•	•	•		•			•	•							
34	7	1208.29	•	•	•		•			•					•			
35	7	1208.29	•	•	•	•	•									•		

NOTE: The results of model fitting for the extended model are identical to those for the design model, as presented above.