

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 I.2d

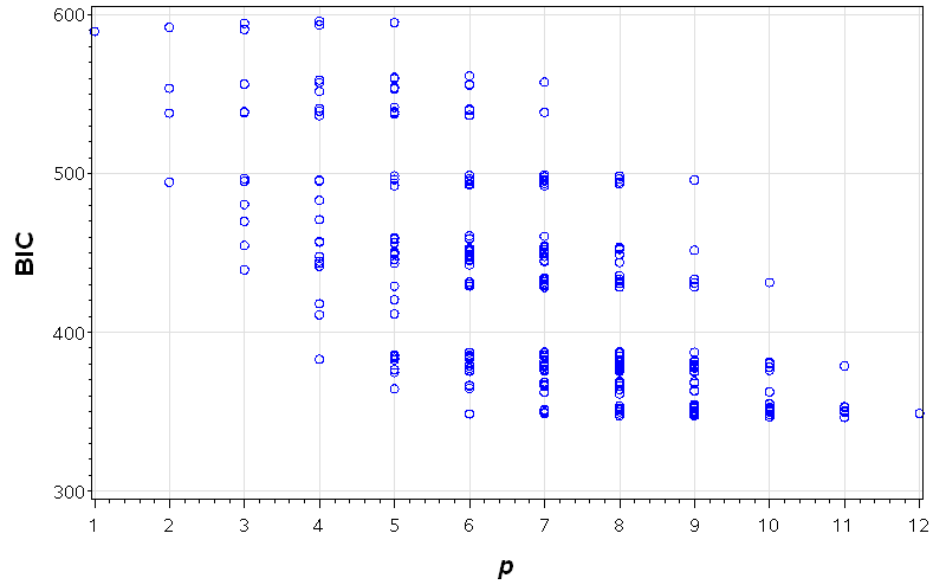
Final Model Fitting

Non-Methane Organic Gases (NMOG) (Bag 1)

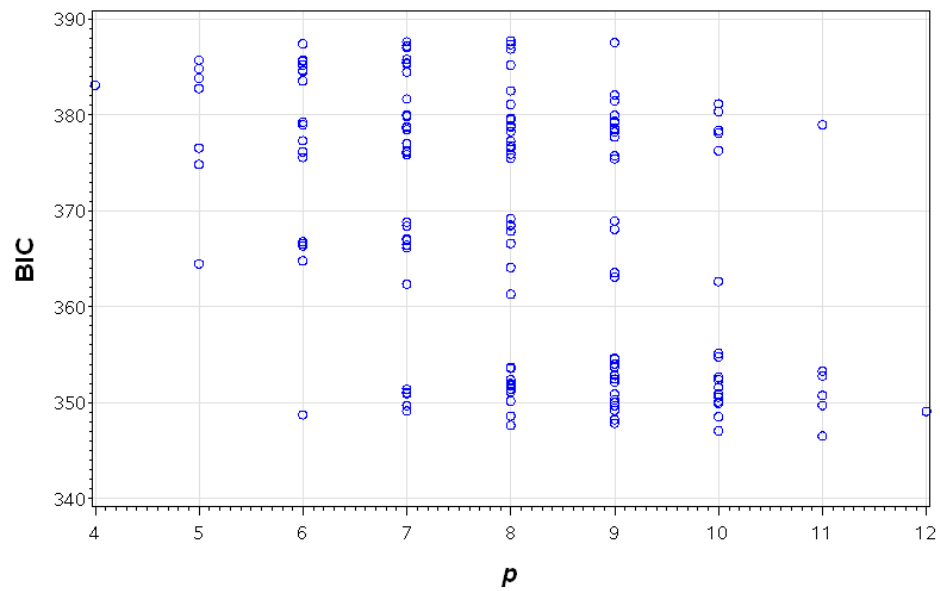
No. Observations:	956
No. Vehicles:	15
No. censored measurements:	0
No. missing measurements:	0
No. measurements removed:	0
Model Type:	Mixed model

I.2d.1 Model fitting with respect to the 11-term design model.

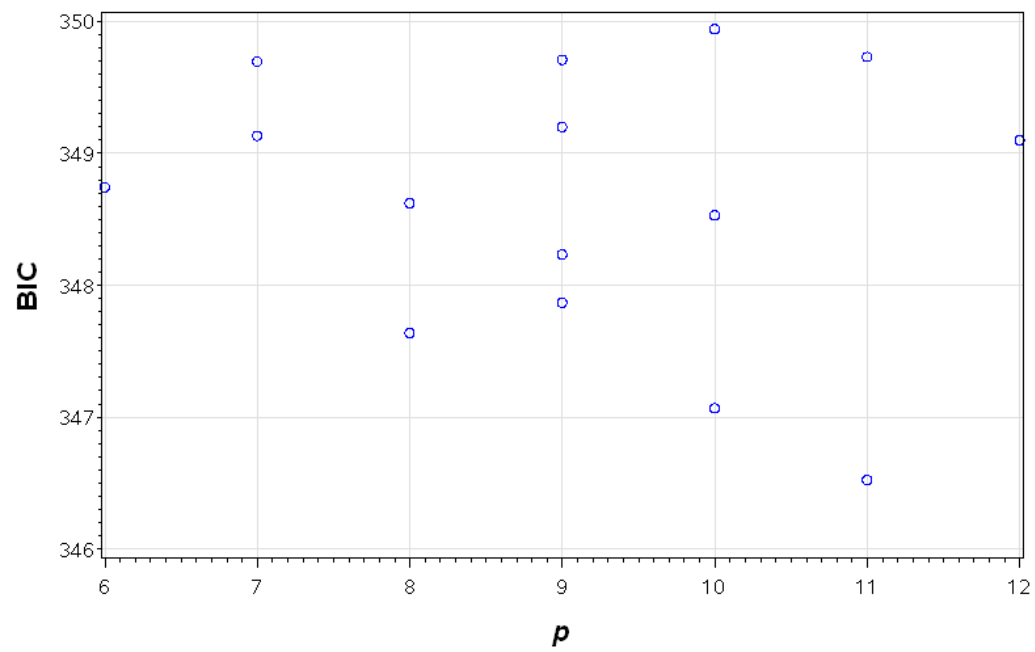
Design Model (11-terms): Bayesian Information Criterion (BIC) vs. number of terms in model (p) for all possible models respecting hierarchy.



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).



NMOG (Bag 1): 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 1-8 comprise the “superset” for final model-fitting).

Rank	<i>p</i>	BIC	Design Terms										
			etOH	Arom	RVP	T50	T90	etOH x etOH	T50 x T50	etOH x Arom	etOH x RVP	etOH x T50	etOH x T90
1	11	346.525	•	•	•	•	•	•	•	•		•	•
2	10	347.069	•	•	•	•	•	•	•			•	•
3	8	347.64	•	•	•	•	•		•				•
4	9	347.871	•	•	•	•		•	•	•		•	
5	9	348.234	•	•	•	•	•		•	•			•
6	10	348.532	•	•	•	•	•	•	•	•		•	
7	8	348.624	•	•	•	•		•	•			•	
8	6	348.746	•	•	•	•			•				
9	12	349.101	•	•	•	•	•	•	•	•	•	•	•
10	7	349.135	•	•	•	•			•	•			
11	9	349.202	•	•	•	•	•	•	•			•	
12	7	349.698	•	•	•	•	•		•				
13	9	349.712	•	•	•	•	•	•	•				•
14	11	349.733	•	•	•	•	•	•	•		•	•	•
15	10	349.944	•	•	•	•		•	•	•	•	•	
16	9	350.005	•	•	•	•	•		•			•	•
17	10	350.101	•	•	•	•	•	•	•	•			•
18	8	350.178	•	•	•	•	•		•	•			
19	9	350.301	•	•	•	•	•		•		•		•
20	10	350.607	•	•	•	•	•		•	•		•	•
21	11	350.763	•	•	•	•	•	•	•	•	•	•	
22	9	350.914	•	•	•	•		•	•		•	•	
23	10	350.925	•	•	•	•	•		•	•	•		•
24	7	350.96	•	•	•	•		•	•				
25	7	351.056	•	•	•	•			•			•	
26	8	351.155	•	•	•	•		•	•	•			
27	7	351.404	•	•	•	•			•		•		
28	8	351.455	•	•	•	•			•	•		•	
29	10	351.619	•	•	•	•	•	•	•		•	•	
30	8	351.751	•	•	•	•			•	•	•		
31	8	351.87	•	•	•	•	•	•	•				
32	8	351.992	•	•	•	•	•		•			•	
33	9	352.154	•	•	•	•	•	•	•	•			
34	8	352.393	•	•	•	•	•		•		•		
35	10	352.393	•	•	•	•	•	•	•		•		•

Models fit for NMOG (Bag 1): (all models include an intercept term).

Model Term	Notation	Model	
		Superset	SM2 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 denotes “Superset minus 2.”			

NMOG (Bag 1): Model fitting history, starting with the 10-term superset model.

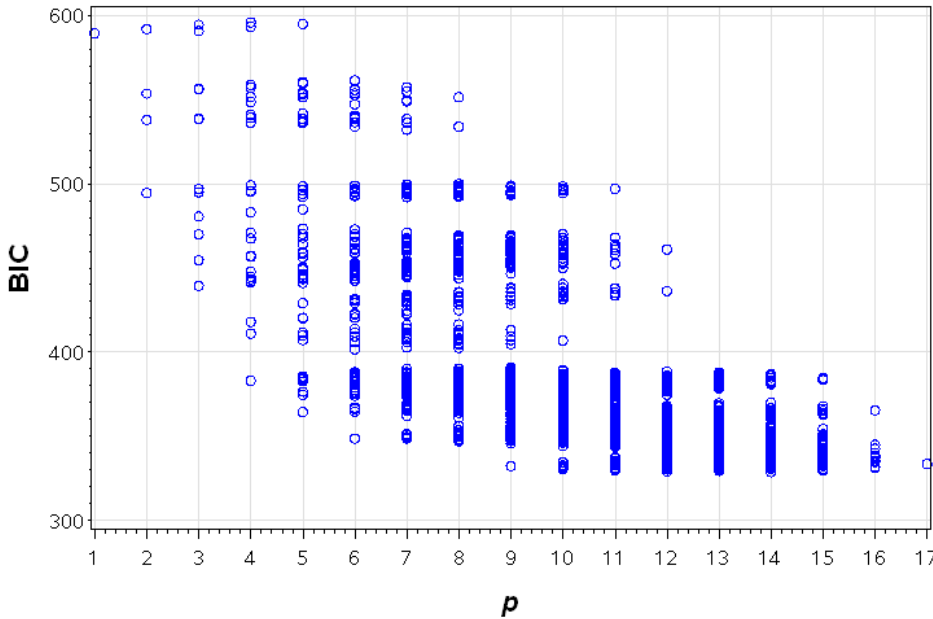
Fit Parameters				<i>Test with respect to Previous Model</i>		
Model	p	$-2\ln L$	BIC ¹	Dev.	d	$\Pr > \chi^2$
Superset ²	11	311.321	346.525			
SM2	9	318.083	347.871	6.762	2	0.034
¹ A lower value indicates a better fit.						
² Best fit with respect to the 11-term design model.						

NMOG (Bag 1): Coefficients and Tests of Effect for the Superset and Reduced Models, with respect to the 11-term design model.

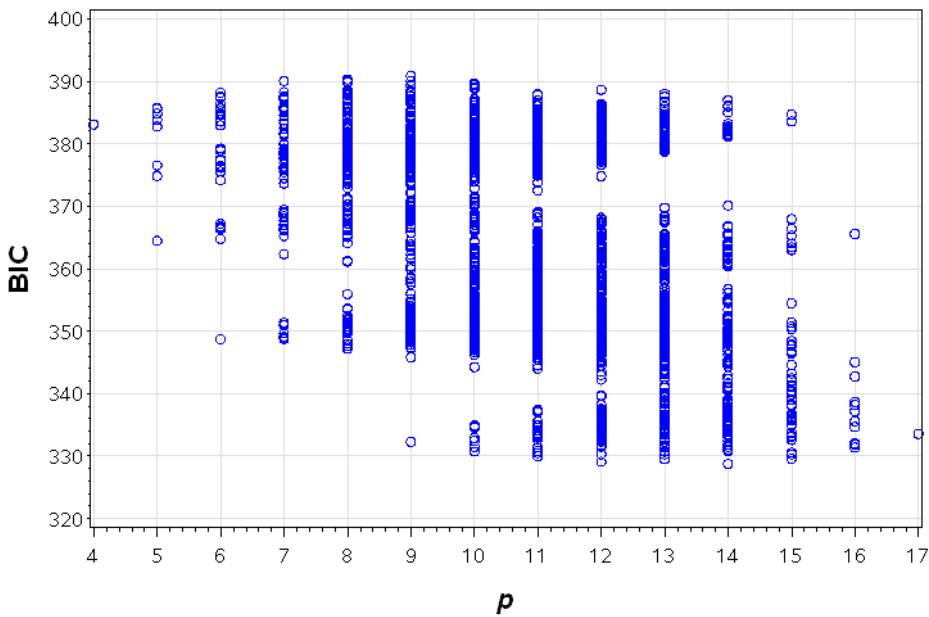
Effect	<i>Superset Model</i>					<i>Reduced Model (Superset)</i>				
	Estimate	Std.Err.	d.f.	t-value	Pr> t	Estimate	Std.Err.	d.f.	t-value	Pr> t
Intercept	-0.9520	0.09077	15	-10.49	<0.0001	Reduced Model = Superset Model				
Z_e	0.07981	0.01326	941	6.02	<0.0001					
Z_a	0.08789	0.00929	941	9.46	<0.0001					
Z_r	-0.04595	0.01053	941	-4.36	<0.0001					
Z_5	0.1344	0.01329	941	10.12	<0.0001					
Z_9	0.01593	0.00925	941	1.72	0.0855					
ZZ_{ee}	0.04594	0.01760	941	2.61	0.00918					
ZZ_{55}	0.07680	0.01336	941	5.75	<0.0001					
ZZ_{ea}	0.01635	0.00906	941	1.80	0.0714					
ZZ_{er}	-	-	-	-	-					
ZZ_{e5}	0.04754	0.01893	941	2.51	0.0122					
ZZ_{e9}	0.01961	0.00902	941	2.17	0.0300					
σ_{veh}^2	0.1224									
σ_{ε}^2	0.07538									

I.2d.2 Model Fitting with respect to the 16-term extended Model.

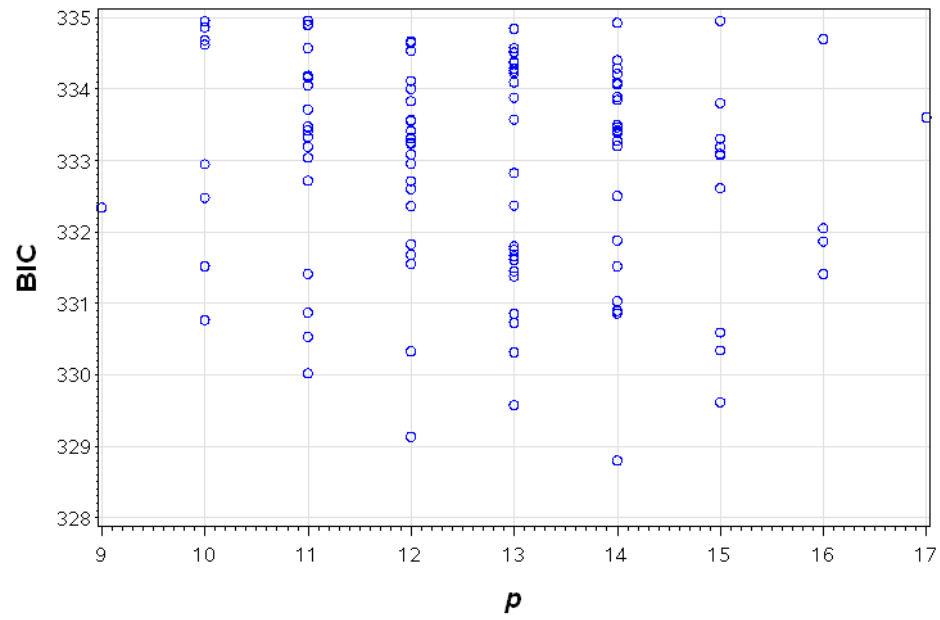
Extended Model (16-terms): Bayesian Information Criterion (BIC) vs. number of terms in model (p) for all possible models respecting hierarchy.



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).



NMOG (Bag 1): 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 1-8 comprise the “superset” for final model-fitting).

Rank	p	BIC	Design Terms										Extended Terms				
			etOH	Arom	RVP	T50	T90	etOH x etOH	T50 x T50	etOH x Arom	etOH x RVP	etOH x T50	etOH x T90	Arom x RVP	Arom x T50	Arom x T90	T50 x T90
1	14	328.80	•	•	•	•	•	•	•		•	•	•		•	•	
2	12	329.14	•	•	•	•	•		•	•			•	•		•	
3	13	329.58	•	•	•	•	•	•	•				•	•		•	
4	15	329.62	•	•	•	•	•	•	•		•	•	•	•		•	
5	11	330.02	•	•	•	•	•		•	•				•		•	
6	13	330.32	•	•	•	•	•	•	•	•		•	•	•		•	
7	12	330.33	•	•	•	•	•	•	•				•	•		•	
8	15	330.35	•	•	•	•	•	•	•	•	•	•	•	•		•	
9	11	330.54	•	•	•	•	•		•					•		•	
10	15	330.60	•	•	•	•	•	•	•	•		•	•	•		•	•
11	13	330.73	•	•	•	•	•	•	•	•		•	•			•	
12	10	330.77	•	•	•	•	•		•				•			•	
13	13	330.86	•	•	•	•	•		•	•				•		•	
14	14	330.87	•	•	•	•	•	•	•	•				•		•	
15	11	330.87	•	•	•	•	•		•	•				•		•	
16	14	330.90	•	•	•	•	•	•	•	•		•	•	•		•	
17	14	331.03	•	•	•	•	•	•	•	•	•	•	•	•		•	
18	13	331.38	•	•	•	•	•	•	•	•				•		•	
19	16	331.41	•	•	•	•	•	•	•	•		•	•	•		•	•
20	11	331.42	•	•	•	•	•		•					•		•	
21	13	331.45	•	•	•	•	•		•	•	•			•		•	
22	10	331.52	•	•	•	•	•		•					•			
23	14	331.52	•	•	•	•	•	•	•	•				•		•	
24	12	331.56	•	•	•	•	•		•	•				•		•	
25	13	331.61	•	•	•	•	•	•	•	•	•			•		•	
26	13	331.66	•	•	•	•	•	•	•			•	•	•		•	
27	12	331.69	•	•	•	•	•	•				•	•			•	
28	13	331.75	•	•	•	•	•		•	•				•		•	•
29	13	331.80	•	•	•	•	•		•	•		•	•			•	
30	12	331.83	•	•	•	•	•		•	•	•			•			
31	12	331.83	•	•	•	•	•	•	•					•		•	
32	16	331.87	•	•	•	•	•	•	•	•	•	•	•	•	•	•	
33	14	331.89	•	•	•	•	•	•	•	•				•		•	•
34	16	332.06	•	•	•	•	•	•	•	•	•	•	•	•		•	•
35	9	332.34	•	•	•	•	•		•					•			

Models fit for NMOG (Bag 1): (all models include an intercept term).

Model Term	Notation	Model		
		Superset	SM3 ¹	SM7
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}	•	•	×

Arom × RVP	ZZ_{ar}	•	•	•
Arom × T50	ZZ_{a5}	•	×	
Arom × T90	ZZ_{a9}	•	•	×
T50 × T90	ZZ_{59}	•	•	×
RVP × T90	ZZ_{r9}	•	×	

¹ denotes “Superset minus 3, etc.”

NMOG (Bag 1): Model fitting history, starting with the 9-term superset model.

Fit Parameters				Test with respect to Previous Model		
Model	p	$-2\ln L$	BIC ¹	Dev.	d	$\Pr > \chi^2$
Superset	17	282.156	333.609			
SM3 ²	14	285.473	328.802	3.317	3	0.345
SM7	10	313.769	346.266	28.296	4	0.000011

¹ A lower value indicates a better fit.
² Best fit with respect to the 16-term extended model.

NMOG (Bag 1): Coefficients and Tests of Effect for the Superset and Reduced Models, with respect to the 16-term extended model.

Effect	<i>Full Model (superset)</i>				
	Estimate	Std. Err.	d.f.	t-value	Pr>t
Intercept	-0.9508	0.09047	15	-10.5	0.00000
Z_e	0.1054	0.01586	941	6.65	0.00000
Z_a	0.1072	0.00995	941	10.8	0.00000
Z_r	-0.03611	0.01339	941	-2.70	0.0071
Z_5	0.1696	0.01767	941	9.60	0.00000
Z_9	0.01217	0.01025	941	1.19	0.24
ZZ_{ee}	0.05186	0.01849	941	2.80	0.0051
ZZ_{55}	0.08968	0.01508	941	5.94	0.00000
ZZ_{ea}	0.03775	0.01496	941	2.52	0.012
ZZ_{er}	0.00726	0.01014	941	0.72	0.47
ZZ_{e5}	0.04249	0.01953	941	2.18	0.030
ZZ_{e9}	0.04148	0.01199	941	3.46	0.00056
ZZ_{ar}	0.04390	0.01620	941	2.71	0.0069
ZZ_{a5}	0.01941	0.01806	941	1.07	0.28
ZZ_{a9}	0.01980	0.01014	941	1.95	0.051
ZZ_{59}	0.05104	0.01349	941	3.78	0.00016
ZZ_{r9}	-0.01130	0.01146	941	-0.985	0.32
σ_{veh}^2	0.1216				
σ_{ε}^2	0.07309				

<i>Reduced Model (SM3)</i>				
Estimate	Std. Err.	d.f.	t-value	Pr>t
-0.9513	0.09042	15	-10.5	0.00000
0.0927	0.01406	941	6.60	0.00000
0.1051	0.00988	941	10.6	0.00000
-0.0483	0.01064	941	-4.54	0.00001
0.1541	0.01514	941	10.2	0.00000
0.0112	0.00961	941	1.17	0.24
0.0420	0.01756	941	2.39	0.017
0.0787	0.01360	941	5.78	0.00000
0.0217	0.00918	941	2.36	0.018
0.0357	0.01914	941	1.87	0.062
0.0476	0.01098	941	4.34	0.00002
0.0272	0.01263	941	2.16	0.031
0.0205	0.00996	941	2.06	0.040
0.0544	0.01201	941	4.53	0.00001
σ_{veh}^2	0.1215			
σ_{ε}^2	0.07335			