ELSEVIER
Journal of Hazardous Materials 73 (2000) 95–104
Journal of Hazardous Materials
www.elsevier.nl/locate/jhazmat

Response to Letter to the Editor

Fuels in Sewers: Behaviour and Countermeasures

Response to letter entitled: *Science or Selective Graphing*

The letter from Mr Figueira was reviewed and this is my response to the issues he raised. The main issue is the questioning of the graphing and consequently, the results of the paper.

This response will consist of three portions. First, the summary data from the papers in question will be reviewed and replotted. Second, the findings of these data will be reported. Third, a reply will be made to specific points that Mr Figueira raised.

The first item to note is that the data Mr Figueira uses is from a paper published about the same time, but focusing on the use of dispersants and not the other countermeasures. This paper, published in an ASTM form, is also attached to this letter. It is important to note that the data contained in the ASTM paper is summarized, as stated very explicitly in that paper, and that the graphs in either paper are not necessarily taken from this table. The summary data published in the ASTM paper covers less than one third of the total runs completed and were intended only to illustrate the results. There was no selectivity in presenting data. The graphs were drawn from fully averaged data sets. Despite that, I will review and replot the summary data to examine whether these values are consistent with the findings noted in the original papers.

The summary data set from the ASTM paper are given here as Table 1. The runs in each set are averaged and given in bold. As will be noted later, some of these data sets should not be averaged because conditions such as flow rates were different; however, this still does not change the overall results. Modern software enables us to quickly calculate statistics on these numbers and this was done as shown in Table 2. This form of analysis is important to determine if there is significance to the differences found in vapour peaks or total vapour concentrations between the different products and test conditions. Table 3 shows the extracted total vapours and their averages extracted from the summary data. Table 4 is a summary table of the total vapour concentrations versus dilution volume. The latter two tables provide summary data analogous to that used to plot the data in the original papers.

The data are most extensive for gasoline only, for Biosolve and for Corexit. Therefore, in the interests of simplicity, these will be plotted in graphs. Fig. 1 shows the peak concentrations at the various manholes using overall experimental averages. This figure is consistent with the plots in the original papers and shows that the peak concentrations of the gasoline vapour at the manholes is substantially increased by the application of Biosolve and Corexit. Referring back to Table 2, we find that the

PII: S0304-3894(99)00173-9

Table 1

Run Description	Run Number		Maximum Vapour at at Manhole, ppt					Total Vapour ppt/min
			2	3	4	5	6	
GASOLINE INJECTION RUNS – FLOW RATE = 2L/MIN								
Gasoline only		44	5.63	2.73	1.28	1.01	1.16	61.4
		45	5.4	2.7	1.25	0.98	1.17	77.1
		51	4.69	2.62	1.28	0.85	1.09	75.5
		131	5.31	1.96	1.1	0.92	0.72	61.9
		132	4.91	2.04	1.14	0.9	0.62	60.4
		133	4.65	1.97	1.13	0.9	0.6	60.2
			5.1	**2.3**	**1.2**	**0.9**	**0.9**	**66.1**
Biosolve	1:1	60	6.63	4.26	2.51	1.45	1.01	91.9
	2:1	47	7.92	4.59	2.51	1.47	1.13	99
	2:1	54	7.31	4.58	2.69	1.54	1.03	94.6
	5:1	67	5.08	3.97	2.31	1.52	0	
	10:1	73	5.71	3.97	2.52	1.7	0.63	84.9
	10:1	134	6.6	3.28	2.11	1.53	0.51	83.8
	10:1	135	6.02	3.02	1.91	1.4	0.48	72.8
	20:1	77	5.69	3.69	2.42	1.73	0.6	77.2
	50:1	80	6.83	3.69	2.52	2	0.62	93.5
			6.4	**3.9**	**2.4**	**1.6**	**0.8**	**86.1**
Corexit	1:1	64	5.49	3.72	2.07	1.16	1.02	78.5
	2:1	52	7.9	4.39	2.54	1.57	0.99	96.7
	2:1	58	6.28	4.25	2.42	1.49	0.95	86.1
	5:1	70	6.15	3.45	2.28	1.55	0.58	89.9
	10:1	76	5.81	3.41	2.18	1.62	0.59	83.9
	20:1	78	5.32	3.31	2.14	1.67	0.55	84.1
	50:1	81	5.78	3.15	2.06	1.77	0.62	92.1
			6.1	**3.7**	**2.2**	**1.5**	**0.8**	**87.3**
Icoshine	1:1	63	5.43	3.75	2.06	1.13	1.09	76.2
	2:1	49	7.02	4.27	2.19	1.31	1.06	88.5
	2:1	56	5.96	4.05	2.24	1.32	0.99	81
	5:1	69	7.74	4.1	2.5	1.54	0.88	91.4
	10:1	75	6.64	3.55	2.24	1.53	0.8	84.6
			6.6	**3.9**	**2.2**	**1.4**	**1**	**84.3**
Jansolve	1:1	61	6.28	3.93	2.24	1.33	1.08	86.9
	2:1	48	7.24	4.38	2.24	1.32	1.09	90.5
	2:1	55	6.38	4.02	2.2	1.31	1.03	85
	5:1	68	5.02	3.67	2.16	1.32	0.6	73.5
	10:1	74	5.69	3.61	2.3	1.46	0.61	80.9
			6.1	**3.9**	**2.2**	**1.3**	**0.9**	**83.4**
Sunlight	1:1	65	5.42	4.06	2.31	1.3	0.83	80.9
	2:1	50	7.26	4.7	2.57	1.45	0.97	100.4
	2:1	57	6.48	4.48	2.64	1.52	1.05	94.8
	5:1	72	5.64	3.74	2.38	1.5	0.58	99.6
			6.2	**4.2**	**2.5**	**1.4**	**0.9**	**93.9**
Lestoil	1:1	66	4.56	3.35	1.74	1.11	0.85	67.6
	2:1	53	6.83	3.95	2.13	1.3	1.04	82.2
	2:1	59	6.32	3.72	2.03	1.23	1.14	81.4
	5:1	71	5.55	3.55	2.21	1.35	0.66	74
			5.8	**3.6**	**2**	**1.2**	**0.9**	**76.3**

Table 1 (continued)

Run Description		Run Number	Maximum Vapour at Manhole, ppt					Total Vapour ppt/min
			2	3	4	5	6	
GASOLINE INJECTION RUNS – FLOW RATE = 1L/MIN								
Gasoline only		109	6.26	2.34	1.34	0.87	0.17	59.3
			6.26	**2.34**	**1.34**	**0.87**	**0.17**	**59.3**
Biosolve	2:1	110	7.81	2.98	2.15	1.35		94.4
	5:1	112	7.87	3.36	2.36	1.79		149.2
	10:1	113	7.83	3.22	2.28	1.77		136.6
			7.8	**3.2**	**2.3**	**1.6**	**0**	**126.7**
Corexit	2:1	115	7.83	2.79	1.87	1.19	0.88	105.5
	5:1	116	7.84	3.13	2.09	1.37		119.2
	10:1	118	7.16	3.15	1.57	1.45		112.1
			7.6	**3**	**1.8**	**1.3**	**0.9**	**112.3**
GASOLINE INJECTION RUNS – FLOW RATE – 3L/MIN								
Gasoline only		98	3.55	1.67	1.12	0.85	0.66	46.4
			3.55	**1.67**	**1.12**	**0.85**	**0.66**	**46.4**
Biosolve	2:1	102	7.89	2.85	2.04	1.26	0.71	69.2
	5:1	100	4.58	2.85	2.16	1.36	0.55	60
	10:1	99	5.02	2.94	2.29	1.44	0.57	67.9
			5.8	**2.9**	**2.2**	**1.4**	**0.6**	**65.7**
Corexit	2:1	103	7.85	2.88	2.05	1.25	0.54	66.9
	5:1	104	6.96	2.63	1.98	1.26	0.54	70.8
	10:1	105	6.94	2.7	2.09	1.3	0.52	67.7
			7.3	**2.7**	**2**	**1.3**	**0.5**	**68.5**
GASOLINE INJECTION RUNS – FLOW RATE – 5L/MIN								
Gasoline only		160	3.78	1.63	1.18	0.58	1.02	45
Corexit	10:1	161	6.01	2.83	2.24		0.68	55.2
GASOLINE INJECTION RUNS – FLOW RATE – 10L/MIN								
Gasoline only		160	3.78	1.63	1.18	0.58	1.02	45
Corexit	10:1	161	6.01	2.83	2.24		0.68	67.8
GASOLINE HIGH MIXING RUNS – FLOW RATE = 2L/MIN								
Biosolve	10:1	83	5.08	2.97	2.18	1.39	0.54	54.7
Corexit	10:1	139	5.73	2.3	1.38	1.05	0.59	72.8
Water	10:1	140	4.23	1.79	1.06	0.79	0.64	55.4
	10:1	141	3.53	1.62				64.7
DIESEL HIGH MIXING RUNS – FLOW RATE = 2L/MIN								
Diesel only		42	11	7.27	3.63	5.19	4.15	258.5
		43	11.7	6.99	3.65	4.64	3.82	268
		46	10.5	6.38	3.72	4.25	3.43	230.9
		95	10.9	4.59	3.42	3.38	1.83	178.5
			11	**6.3**	**3.6**	**4.4**	**3.3**	**234**
Biosolve	2:1	88	11.6	4.74	3.76	4.05	2.19	219.8
	5:1	86	12	5.04	4	4.52	2.31	245.3
	10:1	87	11.1	4.72	3.8	4.33	2.22	226.5
			11.6	**4.8**	**3.9**	**4.3**	**2.2**	**230.5**
Corexit	2:1	89	11.7	4.65	3.8	4.33	2.46	251.9
	5:1	90	11.4	4.53	3.54	4.02	2.17	287.7
	10:1	92	10	3.87	3.11		2.35	186.4
			11	**4.4**	**3.5**	**4.2**	**2.3**	**242**

Table 2
Statistics

Run Description	Run Number	Maximum Vapour Manhole					Total Vapour ppt/min
		2	3	4	5	6	
Gasoline Standard deviation		1.6	1	0.6	0.4	0.3	23.9
Diesel Standard deviation		0.6	1.2	0.2	0.5	0.8	34.5
Total Standard deviation		2.4	1.2	0.8	1.1	0.8	59.8
Gasoline Standard peak deviation		0.78	twice	1.56			
Diesel Standard peak deviation		0.66	peak	1.32			
Total Standard peak deviation		1.26		2.52			

difference is above the standard deviations for data at each manhole and therefore the difference is significant. The difference between Biosolve and Corexit is, however, not significant. Fig. 2 shows the peak concentrations at the manholes for just the averages of the data at the flow rate of 2 L/min. This shows similar results to Fig. 1. There is a significant difference between gasoline and all of the other treatments, but no differences between any of the surfactant agents. Both of these figures look similar to Fig. 5 in the Journal paper.

Table 3
Total Vapours

Gasoline	66.1	Gasoline	**52.4**
	59.3	Biosolve	**83.3**
	46.4	Corexit	**77.3**
	45	Icoshine	84.3
	45	Jansolve	83.4
		Sunlight	93.9
	52.4	Lestoil	76.3
Biosolve	86.1		
	126.7		
	65.7		
	54.7		
	83.3		
Corexit	87.3		
	112.3		
	68.5		
	55.2		
	67.8		
	72.8		
	77.3		
Icoshine	84.3		
Jansolve	83.4		
Sunlight	93.9		
Lestoil	76.3		

Table 4
Effect of Dilution Volume

Total Vapour Concentrations			
Dilution Volume	Gasoline	Biosolve	Corexit
1	59.3	126.7	112.3
2	66.1	86.1	87.3
3	46.4	65.7	68.5
5	45		55.2
10	45		68.5

There are two factors that have relevance to the outcome of the experiments reported, the peak vapour concentration at each manhole and the total integrated concentration. The latter is obtained from mathematically summing the digital data from each of the manhole sensors. Table 3 shows the values from all the runs and the total averages. Fig. 3 shows the graph of the averages, clearly showing that treatment with a surfactant (of any type) increases the total vapour released along the test sewer. This is analogous to Fig. 10 in the Journal paper. It is important to note that the difference between gasoline only and the treatments is above 23.9, the standard deviation. This is then significant. The difference between any of the treatments is not significant.

Table 4 contains the summary data showing the total vapour concentrations with dilution volume. These data are averaged from the summary data in Table 1 (ASTM paper). Fig. 4 shows the plot of these data over the various dilution volumes. Fig. 5 shows these with assumed zero points, similar to what was plotted in the Journal paper,

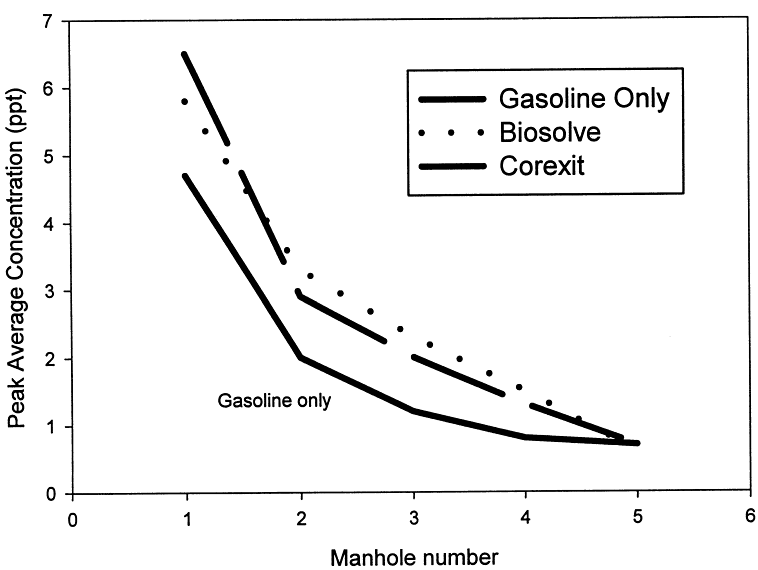

Fig. 1. Vapour Concentration with Biosolve and Corexit Treatment.

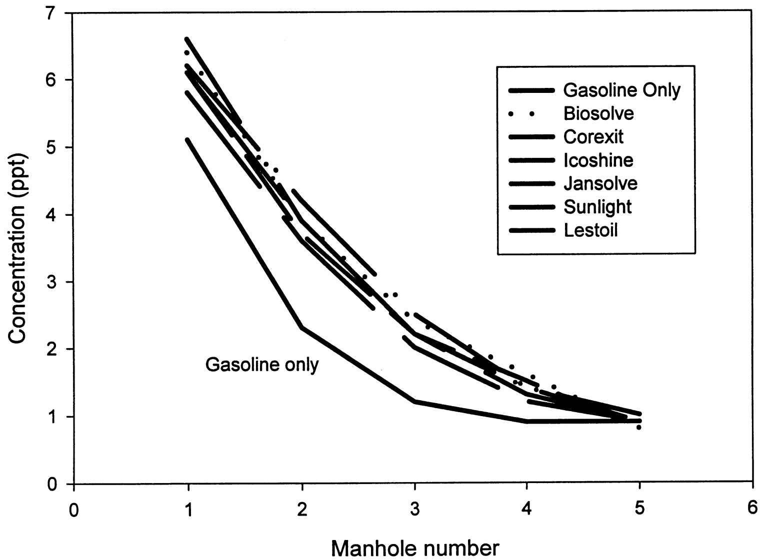

Fig. 2. Vapour Concentrations with Various Treatments.

Fig. 7. The trend between Fig. 4 and Fig. 5 are again similar to the Journal paper, Fig. 7. The vapour concentration goes up with dilution volume, then falls after a dilution volume of 2 to 5. There is a relatively constant difference between the gasoline only and the treatments. It should be borne in mind that the data plotted here, from Table 4, are averages of summary data taken over different conditions, whereas the data in the Journal article are taken under the same conditions — but the findings are still consistent.

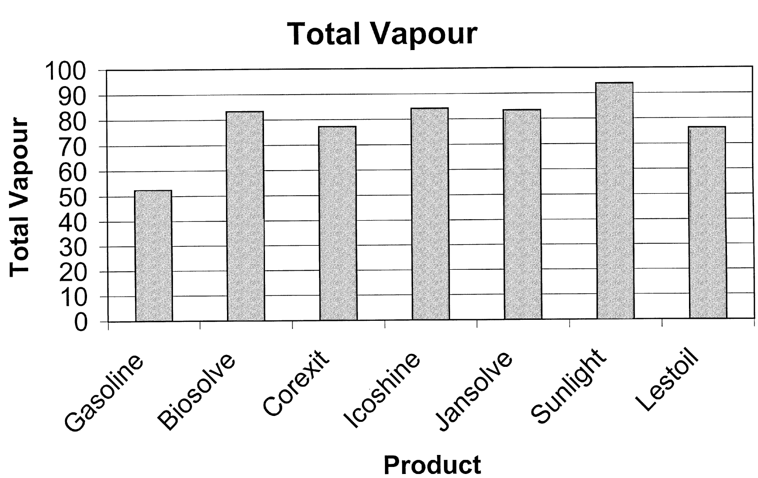

Fig. 3. Averages of Vapour Concentrations Appearing at the Manholes.

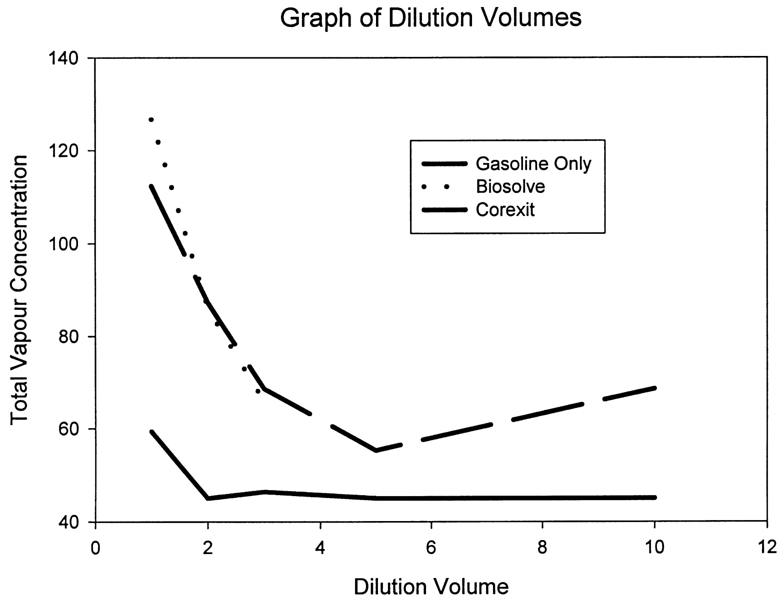

Fig. 4. Effect of Dilution Volumes on Vapour Concentration.

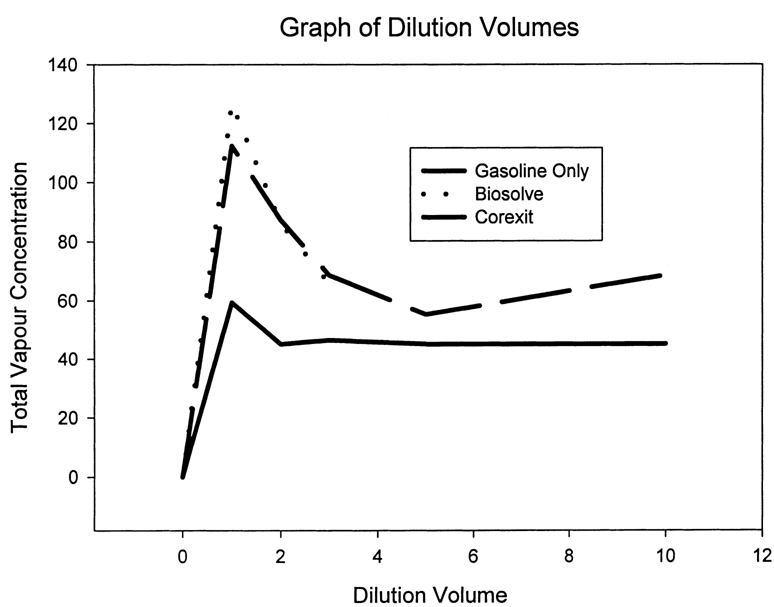

Fig. 5. Effect of Dilution Volumes on Vapour Concentrations with No Dilution Taken as Zero.

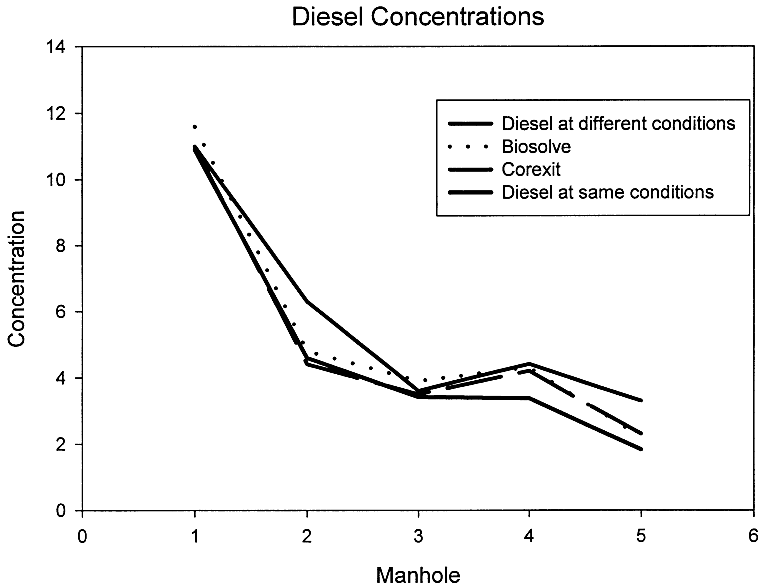

Fig. 6. Diesel Vapour Concentrations with Treatment Type.

The paper notes that diesel fuel does not show the bimodal peaks of the gasoline. The paper makes the point several times that diesel fuel, containing a lot less volatiles, shows far less or little of the behaviour that gasoline does. The summary data given in Table on 1 diesel fuel aggregates the data for diesel under the various flow conditions. The peak vapour concentrations at each manhole are plotted in Fig. 6. This figure shows that there is little difference between the peak vapour concentrations, however, when diesel alone (and at the same flow conditions) is compared with Corexit and Biosolve, its vapour concentrations are slightly lower at manholes 4 and 5. The sum total of diesel at all conditions does not show significantly different vapour concentrations to the Biosolve and Corexit at low flow conditions.

Conclusions

Reviewing the summary data and graphs of this data the following conclusions can be drawn:

1. Treatment by surfactant agents, such as used in the study, significantly increases the peak vapour concentrations of gasoline at the manholes in the model sewer systems.

2. Treatment by surfactant agents increases the total volume of vapour released in the model sewer system.

3. The difference between the diesel fuel vapour, both total and peak, released is similar for treated and untreated spills. Under identical conditions there is a slight increase in peak concentrations in the middle of the sewer system.

4. The conclusions are the same as drawn in the original paper.

Response to Specific Items in the Letter to the Editor

Page 1-Third paragraph to fourth paragraph of page 2 — general comments

Page 2-Fourth paragraph — it is implied that only summary data appears in the ASTM paper. This is untrue; attached is the full ASTM paper. The ASTM paper was prepared about the same time as the Journal paper; however it focused only on the treating agents (and not the other countermeasures). It included summary data, only on the treating agents, focusing on gasoline. This paper is attached. It too was carefully peer-reviewed. The ASTM includes some similar graphs to the Journal article and arrives at the same conclusions as does the Journal paper.

Page 3-Fifth paragraph — it is implied that different conclusions were arrived at in the two papers. Similar conclusions relating to the use of surfactant-containing agents, were in fact arrived at in both papers.

Page 3 to Page 5 — Mr Figueira contends that data were incorrectly or selectively plotted. This is not correct. First, the data in the ASTM paper is only summary data. Second, even plotting the summary data as shown in my response results in similar graphs to the papers, and certainly the same conclusions.

Page 4-Paragraph 2 — It is contended that only the lowest of the diesel was used to plot the vapour comparison for diesel. This is true, but that data is derived from experiments using the same conditions (flows, ratios, etc.) as the data where chemical countermeasures were used.

Page 4-Paragraph 3 — It is contended that the article was designed to 'support a pre-determined hypothesis'. This is incorrect and is judgmental.

Page 6-Figure — Mr Figueira has annotated Fig. 3 from the paper to suggest there is an actual reduction in peak 1 using the dispersant. First, it should be noted, as written in the caption, that this is a real-time display. It is merely a print-out of the computer screen. Actual, calibrated values were used to compile the tables and plot the graphs. Secondly, the paper uses this figure to illustrate the behaviour, not perform quantitation. Thirdly, the total integrated area and peaks do appear to be higher for the dispersed situation, even in this illustration.

Page 7-Fig. 3 — originating from Mr Figueira. The origin of this figure and the data used to create it are unknown and are not consistent with the papers figures or data.

Page 8-Fig. 4 — originating from Mr Figueira. The values used to plot the summary data sheets are not used consistently across conditions. If the summary data only is plotted (see my Fig. 4 or Fig. 5), the conclusions are still the same as the report. They were not incorrectly plotted in the Journal.

Page 9, 10-Diesel Plots — Again, summary data across different conditions was used for these plots by Mr Figueira. See my plot number 6 for the correct plot of the summary data. Since diesel fuel was not the focus of the ASTM article, data for diesel were not extensive in that paper.

Overall

The confusion over the plotting of the data in the Journal paper is largely derived from the fact that the summary data (only about 1/3 of total data) is not necessarily specific for flow conditions, etc. Further, full data were used to plot the graphs. Data tables submitted with the original Journal paper were cut during the review process in the interest of brevity. Data submitted to the ASTM paper were likewise drastically reduced in the interests of brevity. However, the graphs and conclusions are still consistent with the summary data presented in the ASTM paper.

Footnote:

In 1987 Biosolve personnel were invited to view the experiment and accepted this invitation. At that time the experiments and results were detailed and explained. Subsequently, further results were provided to the company. No comments or questions on any part of this were received from Biosolve.

M. Fingos