RESEARCH AND DEVELOPMENT REPORT
ANNISTON PLANT

Report No. 2
Job No. 446-514
Date April 15, 1971

OTHER LOCATIONS	GENERAL OFFICE	ANNISTON PLANT
*W. G. Engman - WGK	D. Danna (2)	J. T. Bell
*P. O. deGarmo - So. 2nd	*P. B. Hodges	J. L. Corder
*A. E. Leisy - WGK	*F. J. Holzapfel	J. L. Etheredge
*A. Rasmussen - WGK	R. M. Kountz	V. R. Haupt
*E. S. Tucker - So. 2nd	*W. B. Papageorge	G. L. Jessee
	*W. R. Richard	J. C. Landwehr/W. F. Taffee
	*J. R. Savage	G. W. Miller /E. G. Wright

Title: Aroclor Pollution Study

Personnel: Ishmeal Ransaw and Andrew Nelson (J. L. Brown)

Problem: Evaluate the removal of Aroclor from the Anniston Plant effluent by carbon adsorption

Justification: Pollution Abatement

Summary: In a 107 day pilot run, approximately 287,000 liters of waste water from the Aroclor sump were treated by passing through a series of four (4) packed-bed adsorbers (each adsorber was a five (5) inch diameter tube packed to a bed depth of 5.5 ft. with Pittsburgh's carbon type Filtrasorb 300). Test runs were made at 2 gpm/ft.^{2}, 4 gpm/ft.^{2} and 6 gpm/ft.^{2} flows. During the first 20 days of this study there were periodic indications of breakthroughs[2]. This problem disappeared after backwashing was initiated on a periodic basis regardless of the pressure drop across the columns.

The following conclusions may be drawn from this study:

1. The Aroclor level of waste water containing average concentrations of 4,795 ppb[1] of Aroclor 1221, 1,525 ppb of Aroclor 1242 and 95 ppb of Aroclor 1254 can be reduced to <10 ppb total Aroclor upon passing through the first carbon bed at a 6 gpm/ft.^{2} flow with an expected carbon loading capacity of 25% (based on the first column).

2. Backwashing frequency will have to be based on a factor other than pressure drop alone. This factor is necessary to prevent the migration of small Aroclor-containing particles

[1] ppb = parts per billion

[2] Breakthrough indicated by effluent concentrations >10 ppb Aroclor.

*Appendix sections not included.

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Summary: (cont'd.)

2. through the carbon bed. The backwash water contains an unacceptable Aroclor concentration; hence will have to be treated before disposal.

3. Based on an experimentally determined 25% loading capacity and 6 gpm/ft.^{2} flow, the capital cost for treating a 200 gpm and 600 gpm is \$25,000 ± 30% and \$45,000 ± 30%, respectively. This cost does not include pumps, engineering or other indirects. The total cost becomes \$99,000 ± 30% for 200 gpm flow and \$129,000 ± 30% for 600 gpm with the inclusion of a carbon reactivation system.

Recommendations:

It is recommended that Aroclor be removed from waste streams that contain 60 mg/l or less solids and Aroclor concentrations not exceeding 10,000 ppb by adsorption in a fixed carbon bed.

Future: A study is presently in progress to evaluate the removal of Aroclor by adsorption on a less expensive adsorbent and then removing the adsorbent by flocculation.

Ishmeal Ransaw
PR&D Chemist

/dp

BACKGROUND:

Anniston PR&D Report No. 1 (Job #446-514, 1/15/71) describes a filtration process in which Aroclor is removed from the waste stream by both filtration of neutralization pit solids and by adsorption of any residual Aroclor on the filtration media (carbon). In this study, influent concentrations (100-8,000 ppb) were consistently reduced to <10 ppb upon passing through a four (4) inch diameter column (packed to a bed depth of 5.5 inches with granular carbon) at flows up to 350 cc/min. The presence of 200-1,000 ppm of inert solid particles (size 1.5-250μ) set a maximum limit on the pressure and flow at which the unit could be operated. It was concluded from this study that:

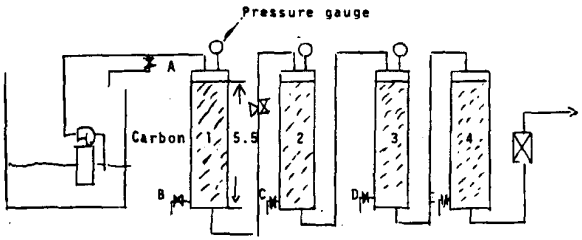
1. An evaluation should be conducted for removing Aroclor in a pilot adsorption unit, and that

2. Such a study should not be conducted on the plant stream without some provision for removing solids.

At that point, it was determined that a solution to the PCB removal problem could be best reached by separating the study into two phases -- solids removal and Aroclor removal. Conventional solutions existed for the solids removal problem so efforts were directed toward the Aroclor removal phase. The Aroclor sump provided the best test conditions for this study as the effluent here contains Aroclor concentrations similar to the total plant effluent, but with less solids. The objective of this study is to define the optimum flow rate and loading capacity for a packed-bed adsorption system for treating the Aroclor waste water. The results of this study are reported herein.

EXPERIMENTAL:

1. Flow Diagram



EXPERIMENTAL: (cont'd.)

2. Equipment Description

a. Piping -- All piping was done with 1/2 inch PVC tubing and connectors..

b. Columns -- Columns (numbered 1, 2, 3 and 4 in diagram) were all identically constructed of clear, heavy duty plastic. Columns measured 6 ft. X 5 in. I.D. Each was equipped with a 5 in. by 1/2 in. reducing flange at the top and bottom. The bottom flange had two separate outlets; one for sampling and one for transfer to the next column. Each column was packed to bed depth of 5.5 ft. (20 pounds) with Pittsburgh carbon (Filtrasorb 300).

c. Feed Pump -- A Jabsco Model P6M6 self-priming pump equipped with a viton head and impeller.

3. General Procedure

Effluent from the Aroclor sump was pumped downflow through the series of packed carbon beds at an initial flow of 2 gpm/ft.^{2} (1,000 cc/min.). The columns were not backwashed during the initial phase of testing because it was not warranted by the pressure drop across the columns. Upon observing periodic breakchroughs, however, it was determined that backwashing could alleviate or eliminate this problem by exposing new carbon surface and preventing channeling. This problem disappeared after backwashing was done periodically for the remainder of the test period regardless of pressure drop. Flow was increased first to 4 gpm/ft.^{2} (2,000 cc/min.) and then to 6 gpm/ft.^{2} (3,000 cc/min.) when there was no indication of a breakthrough of Aroclor. Results are tabulated in Appendix A. Design and cost estimates based on the experimental results are reported in Appendix B.

4. Sampling

A 24 hour composite sample (300 ml.) was taken by catching a 100 ml. sample every eight (8) hours at points A, B, C, D and E. Point A is the influent to Column 1. Points B, C, D and E are respectively the effluents from Columns 1, 2, 3 and 4. Considerable care had to be taken to avoid contamination since the quantity of contaminants was so small. Care was especially taken to prevent the sample from coming into contact with the plastic bottle caps which are known to adsorb Aroclor.

5. Pressure Drop

The unit was never operated at a pressure greater than 10 psig on the head column. A pressure drop of 10 psi was used as a signal to backwash; however, this was not the only signal used for this purpose

EXPERIMENTAL: (cont'd.)

6. Analytical Analysis

The Aroclor was extracted from the aqueous sample into a hexane solvent. Once extracted, the hexane solution was then dried and analyzed on a EC/GC. The concentration of Aroclors 1221, 1242 and 1254 was determined by comparing the main peak height of the unknown with the height of the same peak in the chromatographs of known Aroclor solutions of pure 1221, 1242 and 1254. Not all samples were analyzed. Generally, composites caught every other day were analyzed unless some other factor necessitated running samples in between the said period. Samples not analyzed were stored for future reference. The analytical results are tabulated in Appendix A.

7. Backwashing Frequency and Rate

Each column was generally backwashed every 48 hours except during the first 20 days of operation. This operation was carried out by pumping upflow through each column at an approximate 6 gpm/ft.^{2} flow. This was enough flow to easily expand the compacted carbon beds by 10%. However, this was not always enough flow to expend the carbon bed in the first column. The difficulty experienced in expanding the first column was caused by the agglomeration of Aroclor, Biphenyl, foreign solids and carbon granules at the top of the column. Most of the backwashing time was spent trying to break up this apparent solid mass. The backwash water from the first adsorber was saturated with unadsorbed Aroclor and other organics. The condition of the backwash water indicates that Aroclor is being removed by filtration and adsorption. Backwash water will have to be properly disposed of due to its Aroclor content.

DISCUSSION:

1. Test Results

The results of the 107 day pilot run with respect to the removal of Aroclor is tabulated in Appendix A. These results represent the analysis of 52 sets of samples taken during the test period. Since the analysis time required to complete an analysis is quite lengthy, only the samples considered necessary to define the problem solution were analyzed. With the exception of the brief period in October, results show that the Aroclor was reduced to <10 ppb in the first column. For this reason all calculations are based on the results of the first column.

2. Process Parameters

a. Influent Water Quality -- During the test period approximately 287,000 liters of water was treated with average Aroclor

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DISCUSSION: (cont'd.)

2. Process Parameters (cont'd.)

a. concentrations of 4,795 ppb of Aroclor 1221, 1,525 ppb of Aroclor 1242 and 95 ppb of Aroclor 1254. Aroclor concentrations fluctuated from no detectable amount (NDA) to 90,000 ppb with certain components without any apparent effect on the effluent water quality.

b. Loading Capacity -- Based on the average influent concentrations and volume treated, a minimum of four (4) pounds of Aroclor was removed by 20 pounds of carbon. This represents a 25% loading factor based on Aroclor alone. This does not take into consideration the removal of other organics in the stream, such as Biphenyl. This loading factor could be higher at complete exhaustion since a considerable quantity of Aroclor is actually filtered out.

c. Flow Rate -- The operation of the pilot unit over the flow profile, 2, 4 and 6 gpm/ft.^{2}, seems to have little if any effect on the product water quality. A 6 gpm/ft.^{2} flow was essentially all that could be realized in this unit. This flow does not necessarily represent the optimum flow. This variable probably should be evaluated further where the equipment permits.

ACKNOWLEDGEMENT

I wish to thank Mr. Don Turner, Analytical Lab Technician, who conducted all the Aroclor analyses for this study. Further, I wish to extend gratitude to all the personnel of the analytical lab who helped to monitor pilot operation during off-shift.

Ishmeal Ransaw

/dp

Att.

APPENDIX A

Results of Carbon Adsorption Study

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Startup Time: 10/2/70 @ 1200 hr.

Sample No.		Composite No.	Time of Composite	Date of Composite	Flow Rate cc/min.	Results Concentration of Contaminants (ppb)[1] 1221	1242	1254
1	A	1	1500	10/2	1000			
	B							
	C	2	2300	10/2	1000			
	D							
	E	3	0700	10/3	1000			
		-	-	-	-	-		
2	A	1	1500	10/3	1000			
	B							
	C	2	2300	10/3	1000			
	D							
	E	3	0700	10/4	1000			
		-	-	-	-	-		
3	A	1	1500	10/4	1000			
	B							
	C	2	2300	10/4	1000			
	D							
	E	3	0700	10/5	1000			
		-	-	-	-	-		
Grab	A		0930	10/5	1000	NDA[2]	2000	778
	B					NDA	NDA	NDA
	C					NDA	NDA	NDA
	D					NDA	NDA	NDA
	E					NDA	NDA	NDA
		-	-	-	-	-		
4	A	1	1530	10/5	1000			
	B							
	C	2	2230	10/5	1000			
	D							
	E	3	0615	10/6	1000			
		-	-	-	-	-		
Grab	A		0900	10/6	1000			
	B							
	C							
	D							
	E							

[1] ppb = parts per billion

[2] NDA = non-detectable amount

Sample No.		Composite No.	Time of Composite	Date of Composite	Flow Rate cc/min.	Results Concentration of Contaminants (ppb) 1221	1242	1254
5	A	1	1400	10/6	980	1200	600	NDA
	B					NDA	2	NDA
	C	2	2200	10/6	800	NDA	7	NDA
	D					3	4	NDA
	E	3	0630	10/7	650	12	8	NDA
		-	-	-	-	-		
6	A	1	1420	10/7	1020	347	87	NDA
	B					NDA	2	NDA
	C	2	2200	10/7	860	NDA	3	NDA
	D					NDA	NDA	NDA
	E	3	0815	10/8	740	NDA	NDA	NDA
		-	-	-	-	-		
7	A	1	1600	10/8	1000			
	B							
	C	2	0100	10/9	1000			
	D							
	E	3	0745	10/9	1000			
		-	-	-	-	-		
8	A	1	1630	10/9	1000	1841	630	NDA
	B					17	36	NDA
	C					31	38	NDA
	D					NDA	NDA	NDA
	E					NDA	NDA	NDA
		-	-	-	-	-		

Pump being repaired. Columns shut down from 2015 hr. on 10/9 to 1030 hr. on 10/12.

		-	-	-	-	-		
9	A	1	1600	10/12	1030			
	B							
	C	2	2400	10/13	980			
	D							
	E	3	0800	10/13	650			
		-	-	-	-	-		
10	A	1	1600	10/13	100	860	940	NDA
	B					NDA	10	NDA
	C	2	2400	10/14	980	NDA	14	NDA
	D					NDA	32	NDA
	E	3	0800	10/14	750	NDA	53	NDA

Sample No.		Composite No.	Time of Composite	Date of Composite	Flow Rate cc/min.	Results Concentration of Contaminants (ppb) 1221	1242	1254
11	A	1	1600	10/14	1050			
	B							
	C	2	2400	10/15	980			
	D							
	E	3	0800	10/15	950			
		-	-	-	-	-		
12	A	1	1600	10/15	950	NDA	520	2000
	B					NDA	NDA	NDA
	C	2	2400	10/16	950	NDA	NDA	NDA
	D					NDA	NDA	NDA
	E	3	0800	10/16	800	NDA	NDA	NDA
		-	-	-	-	-		
13	A	1	1600	10/16	850			
	B							
	C	2	2400	10/17	900			
	D							
	E	3	0800	10/17	950			
		-	-	-	-	-		
14	A	1	1600	10/17	1000	NDA	NDA	102
	B					NDA	NDA	NDA
	C	2	2400	10/18	950	NDA	NDA	NDA
	D					NDA	NDA	NDA
	E	3	0800	10/18	1000	NDA	NDA	NDA
		-	-	-	-	-		
15	A	1	1600	10/18	850	NDA	11,361	NDA
	B					NDA	33	NDA
	C	2	2400	10/19	1000	31	12	NDA
	D					63	36	NDA
	E	3	0800	10/19	1000	30	14	NDA
		-	-	-	-	-		
16	A	1	1600	10/19	1000	1483	283	Trace
	B					NDA	NDA	NDA
	C	2	2400	10/20	850	NDA	NDA	NDA
	D					NDA	NDA	NDA
	E	3	0800	10/20	850	NDA	NDA	NDA
		-	-	-	-	-		

Sample No.		Composite No.	Time of Composite	Date of Composite	Flow Rate cc/min.	Results Concentration of Contaminants (ppb) 1221	1242	1254
17	A	1	1600	10/20	1000			
	B					NDA	1	NDA
	C	2	2400	10/21	900			
	D							
	E	3	0830	10/21	800			
		-	-	-	-	-		
Grab	A	1	0915	10/21		79	63	NDA
	B					NDA	NDA	NDA
	C	2				NDA	NDA	NDA
	D					NDA	NDA	NDA
	E	3				NDA	NDA	NDA
		-	-	-	-	-		
Pump out. Unit shut down from 1700 on 10/21 to 1500 on 10/22.								
		-	-	-	-	-		
18	A	1	1600	10/22	1000			
	B							
	C	2	2430	10/23	800			
	D							
	E	3	0830	10/23	800			
		-	-	-	-	-		
19 (Grab)	A		0930	10/23	1000			
	B							
	C							
	D							
	E							
		-	-	-	-	-		
Unit shut down two hours to backwash at 0950 10/23.								
		-	-	-	-	-		
20	A	1	1600	10/23	1000			
	B							
	C	2	2400	10/24	1000			
	D							
	E	3	0800	10/24	1000			
		-	-	-	-	-		

Sample No.		Composite No.	Time of Composite	Date of Composite	Flow Rate cc/min.	Results Concentration of Contaminants (ppb) 1221	1242	1254
21	A	1	0900	10/25	1000	NDA	1250	NDA
	B					2	2	NDA
	C	2	2400	10/25	1000	5	4	NDA
	D					2	NDA	NDA
	E	3	0800	10/26	100	NDA	2	NDA
		-	-	-	-	-		
Unit down two hours for pump repair on 10/25. Unit down four hours to backwash, 10/26.								
		-	-	-	-	-		
22	A	1	1600	10/26	1500	NDA	84	Trace
	B					NDA	11	Trace
	C	2	2400	10/27	1400	NDA	2	Trace
	D					NDA	4	Trace
	E	3	0800	10/27	1400	NDA	3	Trace
		-	-	-	-	-		
23	A	1	1600	10/27	1360	230	112	108
	B					NDA	3	NDA
	C	2	2400	10/28	1300	NDA	26	NDA
	D					NDA	NDA	NDA
	E	3	0800	10/28	1300	NDA	NDA	NDA
		-	-	-	-	-		
Unit down one hour to backwash 10/28.								
		-	-	-	-	-		
24	A	1	1600	10/28	2100			
	B							
	C	2	0145	10/29	2100			
	D							
	E	3	0800	10/29	2100			
		-	-	-	-	-		
25	A	1	1600	10/29	2100	NDA	NDA	500
	B					NDA	NDA	NDA
	C	2	2400	10/30	2100	NDA	NDA	NDA
	D					NDA	NDA	2
	E	3	0800	10/30	2100	NDA	NDA	2
		-	-	-	-	-		

Sample No.		Composite No.	Time of Composite	Date of Composite	Flow Rate cc/min.	Results Concentration of Contaminents (ppb) 1221	1242	1254
26	A	1	1600	10/30	2100	132	174	NDA
	B					NDA	NDA	NDA
	C	2	0100	10/31[3]	2100	NDA	NDA	NDA
	D					NDA	NDA	NDA
	E	3	0800	11/2	2100	NDA	NDA	NDA
		-	-	-	-	-		
27	A	1	1600	11/2	1900			
	B							
	C	2						
	D							
	E	3	0800	11/3	1700			
		-	-	-	-	-		
Unit shut down one hour -- columns backwashed.								
		-	-	-	-	-		
28	A	1	1600	11/3	2100			
	B							
	C	2	2430	11/4	2100			
	D							
	E	3	0830	11/4	2100			
		-	-	-	-	-		
Grab	A					NDA	530	NDA
	B		1000	11/4	2100	NDA	NDA	NDA
	C					NDA	NDA	NDA
	D					NDA	NDA	NDA
	E					NDA	NDA	NDA
		-	-	-	-	-		
29	A	1	1600	11/4	2100			
	B							
	C	2	2400	11/5	2100			
	D							
	E	3	0830	11/5	2100			
		-	-	-	-	-		
30	A	1	1600	11/5	2100	NDA	250	NDA
	B					NDA	NDA	NDA
	C	2	2400	11/6	2000	NDA	NDA	NDA
	D					NDA	NDA	NDA
	E	3	0830	11/6	2100	NDA	NDA	NDA

[3]The composite was continued without the realization that samples had not been taken 11/1.

Sample No.		Composite No.	Time of Composite	Date of Composite	Flow Rate cc/min.	Results Concentration of Contaminants (ppb) 1221	1242	1254
31	A	1	1600	11/6	2100			
	B							
	C	2	0100	11/7	2000			
	D							
	E	3	0800	11/7	2100			
		-	-	-	-	-		
Unit shut down one hour to backwash columns on 11/7.								
		-	-	-	-	-		
32	A	1	1600	11/7	2000			
	B							
	C	2	0100	11/8	2000			
	D							
	E	3	0800	11/8	2000			
		-	-	-	-	-		
33	A	1	1600	11/8	2000	NDA	124	NDA
	B					NDA	NDA	NDA
	C	2	2400	11/9	2000	NDA	NDA	NDA
	D					NDA	NDA	NDA
	E	3	0800	11/9	2000	NDA	NDA	NDA
		-	-	-	-	-		
34	A	1	1600	11/9	2000	940	770	NDA
	B					NDA	10	NDA
	C	2	0100	11/10	2000	NDA	3	NDA
	D					NDA	NDA	NDA
	E	3	0815	11/10	2100	NDA	NDA	NDA
		-	-	-	-	-		
35	A	1	1600	11/10	2100			
	B							
	C	2	0100	11/11	2100			
	D							
	E	3	0800	11/11	2100			
		-	-	-	-	-		
Columns backwashed on 11/10 -- downtime, one hour.								

Sample No.		Composite No.	Time of Composite	Date of Composite	Flow Rate cc/min.	Results Concentration of Contaminants (ppb) 1221	1242	1254
36	A	1	1600	11/11	2000	NDA	150	Trace
	B					NDA	NDA	NDA
	C	2	0100	11/12	2000	NDA	NDA	NDA
	D					NDA	NDA	NDA
	E					NDA	NDA	NDA
		-	-	-	-	-		
Grab	A		1000	11/12	2000			
	B							
	C							
	D							
	E							
		-	-	-	-	-		
Columns backwashed 11/12 -- one hour downtime.								
		-	-	-	-	-		
37	A	1	1600	11/12	2100			
	B							
	C	2	0100	11/13	2100			
	D							
	E	3	0830	11/13	2100			
		-	-	-	-	-		
38	A	1	1600	11/13	2100	NDA	3060	Trace
	B					NDA	NDA	NDA
	C	2	2400	11/14	2000	NDA	NDA	NDA
	D					NDA	NDA	NDA
	E	3	0800	11/14	2000	NDA	NDA	NDA
		-	-	-	-	-		
39	A	1	1600	11/14	2060			
	B							
	C	2	2400	11/15	2000			
	D							
	E	3	0800	11/15	2100			
		-	-	-	-	-		
Unit down one hour. Columns backwashed on 11/15.								
		-	-	-	-	-		

Sample No.		Composite No.	Time of Composite	Date of Composite	Flow Rate cc/min.	Results Concentration of Contaminants (ppb) 1221	1242	1254
40	A	1	1600	11/15	2100	NDA	78	NDA
	B					NDA	NDA	NDA
	C	2	2400	11/16	2000	NDA	NDA	NDA
	D					NDA	NDA	NDA
	E	3	0830	11/16	2100	NDA	NDA	NDA
		-	-	-	-	-		
41	A	1	1600	11/16	2000			
	B	2	2400	11/17	1900			
	C							
	D							
	E	3	0815	11/17	2000			
		-	-	-	-	-		
42	A	1	1600	11/17	2000	NDA	5200	Trace
	B					NDA	NDA	NDA
	C	2	2400	11/18	1900	NDA	NDA	NDA
	D					NDA	NDA	NDA
	E	3	0830	11/18	2000	NDA	NDA	NDA
		-	-	-	-	-	-	
43	A	1	1535	11/18	2000			
	B							
	C	2	2400	11/19	1900			
	D							
	E	3						
		-	-	-	-	-		
44	A	1	1600	11/19	2000	NDA	1875	Trace
	B					NDA	NDA	NDA
	C	2	2400	11/20	1900	NDA	NDA	NDA
	D					NDA	9	NDA
	E	3	0810	11/20	2000	NDA	NDA	NDA
		-	-	-	-	-		

Columns backwashed on 11/19. One hour downtime.

		-	-	-	-	-		
45	A	1	1600	11/20	1670			
	B							
	C	2	2400	11/21	1670			
	D							
	E	3	0800	11/21	1670			

Sample No.		Composite No.	Time of Composite	Date of Composite	Flow Rate cc/min.	Results Concentration of Contaminants (ppb) 1221	1242	1254
46	A	1	1600	11/21	1670	NDA	640	Trace
	B					NDA	NDA	NDA
	C	2	2400	11/22	1670	NDA	NDA	NDA
	D					NDA	NDA	NDA
	E	3	0800	11/22	1670	NDA	NDA	NDA
		-	-	-	-	-		
47	A	1	1600	11/22	1800			
	B							
	C	2	2400	11/23	1800			
	D							
	E	3	0800	11/24	1800			
		-	-	-	-	-		
Grab	A		1600	11/24	1800			
	B							
	C							
	D							
	E							
		-	-	-	-	-		

Columns down five hours on 11/25. Columns backwashed, pump repaired.

		-	-	-	-	-		
48	A	1	1600	11/25	3000	NDA	36	80
	B					NDA	NDA	NDA
	C	2	2400	11/26	3000	NDA	NDA	NDA
	D					NDA	NDA	NDA
	E	3	0800	11/26	3000	NDA	NDA	NDA
		-	-	-	-	-		
49	A	1	1700	11/26	3000	NDA	10,800	NDA
	B					NDA	14	NDA
	C	2	2400	11/27	3000	NDA	NDA	NDA
	D					NDA	NDA	NDA
	E	3	0900	11/27	3000	NDA	NDA	NDA
		-	-	-	-	-		
50	A	1	1700	11/27	2800	NDA	NDA	NDA
	B					NDA	NDA	NDA
	C	2	2400	11/28	2650	NDA	NDA	NDA
	D					NDA	NDA	NDA
	E	3	0800	11/28	2750	NDA	NDA	NDA

Sample No.		Composite No.	Time of Composite	Date of Composite	Flow Rate cc/min.	Results Concentration of Contaminants (ppb) 1221	1242	1254
51	A	1	1700	11/28	2500			
	B							
	C	2	0200	11/29	2300			
	D							
	E	3	0730	11/29	3000			
		-	-	-	-	-		
52	A	1	1730	11/29	2400	NDA	NDA	212
	B					NDA	NDA	NDA
	C	2	0130	11/30	2400	NDA	NDA	NDA
	D					NDA	NDA	NDA
	E	3	0800	11/30	2400	NDA	NDA	NDA
		-	-	-	-	-		
Columns backwashed -- two hour downtime.								
53	A	1	1600	11/30	3300			
	B							
	C	2	2400	12/1	3000			
	D							
	E	3	0800	12/1	3000			
		-	-	-	-	-		
54	A	1	1600	12/1	3000	NDA	310	240
	B					NDA	NDA	NDA
	C	2	2400	12/2	2700	NDA	9	4
	D						No sample	
	E	3	0800	12/2	2700	NDA	NDA	NDA
		-	-	-	-	-		
55	A	1	1600	12/2	3200	1383	137	NDA
	B					NDA	NDA	NDA
	C	2	0100	12/3	2800	NDA	NDA	NDA
	D					NDA	NDA	NDA
	E	3	1000	12/3	3000	NDA	NDA	NDA
		-	-	-	-	-		
Columns backwashed on 12/2. Two hours downtime.								
		-	-	-	-	-		

Sample No.	Composite No.	Time of Composite	Date of Composite	Flow Rate cc/min.	Results Concentration of Contaminants (ppb) 1221	1242	1254
56 A	1	1600	12/3	3200	400	86	NDA
B					NDA	NDA	NDA
C	2	2400	12/4	2800	NDA	NDA	NDA
D					NDA	NDA	NDA
E	3	0800	12/4	3000	NDA	NDA	NDA
	-	-	-	-	-		
Grab A		1100	12/5	3000			
B							
C							
D							
E							
	-	-	-	-	-		
Columns backwashed on 12/4 -- one hour downtime.							
	-	-	-	-	-		
57 A	1	1600	12/5	2800			
B							
C							
D							
E	3	0800	12/6	1500			
	-	-	-	-	-		
Pump out on 12/6. One hour downtime.							
	-	-	-	-	-		
58 A	1	1600	12/6	3000			
B							
C							
D							
E	3	0800	12/7	3100			
	-	-	-	-	-		
59 A	1	1600	12/7	3100	9000	1150	NDA
B					NDA	NDA	NDA
C	2	0100	12/8	3000	NDA	NDA	NDA
D					NDA	3	NDA
E	3	0800	12/8	3000	NDA	3	NDA
	-	-	-	-	-		
Columns backwashed on 12/7. Two hours downtime.							

Sample No.		Composite No.	Time of Composite	Date of Composite	Flow Rate cc/min.	Results Concentration of Contaminants (ppb) 1221	1242	1254
60	A							
	B							
	C	2	0100	12/9	3000			
	D							
	E	3	0800	12/9	2850			
		-	-	-	-	-		
Columns backwashed on 12/9 -- 1.5 hours downtime.								
		-	-	-	-	-		
61	A	1	1600	12/9	3000	490	820	NDA
	B					NDA	NDA	NDA
	C	2	0100	12/10	1500	NDA	NDA	NDA
	D					NDA	NDA	NDA
	E					NDA	NDA	NDA
		-	-	-	-	-		
Pump repaired -- three hours downtime on 12/10.								
		-	-	-	-	-		
62	A	1	1600	12/10	3300			
	B							
	C	2	0100	12/11	3000			
	D							
	E	3	0800	12/11				
		-	-	-	-	-		
Columns backwashed. Two hours downtime on 12/11.								
		-	-	-	-	-		
63	A	1	1700	12/11	3500	NDA	430	Trace
	B					NDA	NDA	NDA
	C	2	2400	12/12	3200	NDA	NDA	NDA
	D					NDA	NDA	NDA
	E	3				NDA	NDA	NDA
		-	-	-	-	-		
64	A	1	1600	12/12	3300			
	B							
	C	2	0100	12/13	3200			
	D							
	E							

Sample No.		Composite No.	Time of Composite	Date of Composite	Flow Rate cc/min.	Results Concentration of Contaminants (ppb) 1221	1242	1254
65	A	1	1600	12/13	3500	2850	3100	Trace
	B					NDA	NDA	NDA
	C	2	2400	12/14	3300	NDA	NDA	NDA
	D					NDA	NDA	NDA
	E	3	0800	12/14	3300	NDA	NDA	NDA
		-	-	-	-	-		
Columns backwashed. Two hours downtime on 12/14.								
		-	-	-	-	-		
66	A	1	1600	12/14	3100	8400	1800	NDA
	B					NDA	NDA	NDA
	C	2	2430	12/15	3200	NDA	NDA	NDA
	D					NDA	NDA	NDA
	E	3	0800	12/15	3100	NDA	NDA	NDA
		-	-	-	-	-		
67	A	1	1600	12/15	3000	5100	1183	Trace
	B					NDA	NDA	NDA
	C	2	2400	12/16	3300	NDA	NDA	NDA
	D					NDA	NDA	NDA
	E	3	0800	12/16	3100	NDA	NDA	NDA
		-	-	-	-	-		
Columns backwashed -- 1.5 hours downtime on 12/16.								
		-	-	-	-	-		
68	A	1	1600	12/16	3500	6500	1700	NDA
	B					NDA	NDA	NDA
	C	2	0100	12/17	3200	NDA	NDA	NDA
	D					NDA	NDA	NDA
	E	3	0800	12/17	3200	NDA	NDA	NDA
		-	-	-	-	-		
Grab	A		0800	12/18	3000	15,250	3850	NDA
	B					NDA	NDA	NDA
	C					NDA	NDA	NDA
	D					NDA	NDA	NDA
	E					NDA	NDA	NDA
		-	-	-	-	-		

Sample No.		Composite No.	Time of Composite	Date of Composite	Flow Rate cc/min.	Results Concentration of Contaminents (ppb) 1221	1242	1254
Columns backwashed -- two hours downtime on 12/18.								
		-	-	-	-	-		
69	A	1	1600	12/18	3400			
	B							
	C	2	0200	12/19	3300			
	D							
	E							
		-	-	-	-	-		
70	A	1	1600	12/19	3300			
	B							
	C	2	0300	12/20	3100			
	D							
	E							
		-	-	-	-	-		
71	A	1	1600	12/20	3200	4900	450	Trace
	B					NDA	NDA	NDA
	C	2	0400	12/21	3300	NDA	NDA	NDA
	D					NDA	NDA	NDA
	E	3	0800	12/21	2800	NDA	NDA	NDA
		-	-	-	-	-		
Columns backwashed. Two hours downtime on 12/20.								
		-	-	-	-	-		
72	A	1	1600	12/21	3300	950	84	Trace
	B					NDA	NDA	NDA
	C					NDA	NDA	NDA
	D					NDA	NDA	NDA
	E	3	0800	12/22	3500	NDA	NDA	NDA
		-	-	-	-	-		
73	A	1	1600	12/22	3500	17,250	4150	Trace
	B					NDA	NDA	NDA
	C	2	0300	12/23	3500	NDA	NDA	NDA
	D					NDA	NDA	NDA
	E	3	0800	12/23	3500	NDA	NDA	NDA
		-	-	-	-	-		

Sample No.		Composite No.	Time of Composite	Date of Composite	Flow Rate cc/min.	Results Concentration of Contaminants (ppb) 1221	1242	1254
Columns backwashed on 12/22. Two hours downtime.								
		-	-	-	-	-		
74	A	1	1600	12/23	3000	30,000	9250	Trace
	B					NDA	NDA	NDA
	C					NDA	NDA	NDA
	D					NDA	NDA	NDA
	E	3	0900	12/24	3000	NDA	NDA	NDA
		-	-	-	-	-		
75	A	1	1700	12/24	2800	90,000	6600	Trace
	B					NDA	NDA	NDA
	C	2	2400	12/25	1600	NDA	NDA	NDA
	D					NDA	NDA	NDA
	E					NDA	NDA	NDA
		-	-	-	-	-		
Columns backwashed, pump repaired. Two hours downtime on 12/25.								
		-	-	-	-	-		
76	A	1	1700	12/25	2500			
	B							
	C	2	0200	12/26	2600			
	D							
	E	3	0810	12/26	2600			
		-	-	-	-	-		
77	A	1	1700	12/26	2600	6150	1250	NDA
	B					NDA	NDA	NDA
	C	2	2400	12/27	2800	NDA	NDA	NDA
	D					NDA	NDA	NDA
	E	3	0820	12/27	2800	NDA	NDA	NDA
		-	-	-	-	-		
78	A	1	1700	12/27	2600			
	B							
	C	2	0300	12/28	1400			
	D							
	E							
		-	-	-	-	-		

Sample No.		Composite No.	Time of Composite	Date of Composite	Flow Rate cc/min.	Results Concentration of Contaminants (ppb) 1221	1242	1254
Pump repaired, columns backwashed. Two hours downtime on 12/28.								
		-	-	-	-	-		
79	A	1	1530	12/28	3100	5400	510	Trace
	B					2	Trace	Trace
	C	2	0100	12/29	3300	NDA	NDA	NDA
	D					NDA	NDA	NDA
	E	3	0800	12/29	3400	NDA	NDA	NDA
		-	-	-	-	-		
80	A	1	1600	12/29	3400	9625	248	Trace
	B					NDA	NDA	NDA
	C					NDA	NDA	NDA
	D					NDA	NDA	NDA
	E	3	0815	12/30	3400	NDA	NDA	NDA
		-	-	-	-	-		
81	A	1	1530	12/30	3300	6000	215	Trace
	B					NDA	NDA	NDA
	C	2	0330	12/31	3000	NDA	NDA	NDA
	D					NDA	NDA	NDA
	E	3	0845	12/31	2900	NDA	NDA	NDA
		-	-	-	-	-		
Columns backwashed on 12/31 -- 1.5 hours downtime.								
		-	-	-	-	-		
82	A	1	1530	12/31	3400	1150	80	917
	B					NDA	NDA	NDA
	C	2	0330	01/1	3450	NDA	NDA	NDA
	D					NDA	NDA	NDA
	E	3	0715	01/1	3200	NDA	NDA	NDA
		-	-	-	-	-		
83	A	1	1600	01/1	3400			
	B							
	C	2						
	D							
	E	3	0700	01/2	3300			
		-	-	-	-	-		

Sample No.		Composite No.	Time of Composite	Date of Composite	Flow Rate cc/min.	Results Concentration of Contaminants (ppb) 1221	1242	1254
84	A	1	1600	01/2	3200			
	B							
	C	2	2400	01/3	3000			
	D							
	E	3	0700	01/3	2950			
		-	-	-	-	-		
85	A	1	1600	01/3	3300	13,500	500	Trace
	B					NDA	NDA	NDA
	C	2	2400	01/4	3200	NDA	NDA	NDA
	D					NDA	NDA	NDA
	E	3	0800	01/4	3000	NDA	NDA	NDA
		-	-	-	-	-		

Columns backwashed on 1/4 -- 1.5 hours downtime.

		-	-	-	-	-		
86	A	1	1515	01/4	3400			
	B							
	C	2	2400	01/5	3200			
	D							
	E	3	0930	01/5	3200			
		-	-	-	-	-		
87	A	1	1600	01/5	3200	8000	638	Trace
	B					NDA	NDA	NDA
	C	2	2400	01/6	3200	NDA	NDA	NDA
	D					NDA	NDA	NDA
	E	3	0800	01/6	3200	NDA	NDA	NDA
		-	-	-	-	-		

Columns shut down at 1200 hr. on 1/6/71.

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APPENDIX B

Design and Cost Estimates Based on the Experimental Results (Reported in Appendix A) by Pittsburgh Carbons (Calgon Division) Representative, Mr. Vincent A. Brunotts.

CALGON CORPORATION
SUBSIDIARY OF MERCK & CO., INC.

WATER MANAGEMENT DIVISION CALGON CORPORATION CALGON CENTER BOX 9346 PITTSBURGH, PA. 15230 (412) 923-2345

March 11, 1971

Mr. Ishmeal Ransaw
Monsanto Company
Anniston, Alabama 36201

Dear Mr. Ransaw:

This is in reply to your letter of January 20, 1971 requesting design and cost information for a waste water treatment system utilizing Calgon's Filtrasorb granular activated carbon sized to handle flows of 200 and 600 gpm.

The design basis and cost estimates are based upon data obtained from your pilot plant operation from October 2, 1970 to January 16, 1971.

I apologize for the delay in getting this information to you. The results of your testing are very encouraging as to the feasibility of treating your waste with Filtrasorb granular activated carbon. No doubt, you will have additional questions after you have reviewed this information. Please feel free to contact me or our Birmingham Office as the following address:

Calgon Corporation
25 West Oxmoor Road
Birmingham, Alabama 35209
Mr. Joseph DiGiacinto
Telephone: (205) 879-4763

Thank you for your interest in our products and services.

Very truly yours,

WATER MANAGEMENT DIVISION

Vincent A. Brunotts

Vincent A. Brunotts
Assistant Product Manager
Filtrasorb Department

VAB:bjg
Enclosure

MONSANTO COMPANY - ANNISTON, ALABAMA

SUMMARY OF PILOT PLANT OPERATION

The purpose of the pilot plant was to determine the feasibility of treating Monsanto Company's waste water with Filtrasorb granular activated carbon. The pilot plant was operated from October 2, 1970 through January 16, 1971. The total waste water volume throughput was approximately 267,000 liters. The pilot carbon columns were monitored for breakthrough of contaminants identified as "A", "B" and "C."

Contaminant A had a range of influent concentrations from 0 to 90,000 ppb. Contaminant B had a range of concentrations in the influent from 0 to 11,361 ppb. Contaminant C had an influent concentration ranging from 0 to 2,000 ppb. There was a total of 107 days operation and samples were analyzed on 52 days. Twenty-two (22) of the 52 samples taken had a 0 concentration of contaminant A. Four (4) of the 52 samples taken had a 0 concentration of contaminant B. Twenty-four (24) of the 52 samples taken had 0 concentration of contaminant C. Nineteen (19) of the samples taken had a trace concentration of contaminant C. Based on this data the average concentrations of contaminants A, B and C were 4,795 ppb, 1,525 ppb and 95 ppb, respectively. These average concentrations include the days on which there were a 0 or trace concentrations.

The first carbon column showed a periodic breakthrough of contaminant B during the early part of the testing. However, in the latter period of the testing there was little or no breakthrough of any contaminant. Based on this data, it would be safe to assume that most of the organic was adsorbed in the first column, and that the residence time contained in the first column is sufficient for treatment.

Therefore, on this basis, the total pounds of organics adsorbed in the first column was four pounds. The amount of carbon in the first column was twenty pounds. Thus, the organic loading from this data would indicate a 25% loading. This 25% loading is not necessarily the ultimate loading because there was no breakthrough on the first column. There is no indication on how long the first column would have run. Therefore, the proposed plant design and cost estimate are based on a 25% loading. This loading could be as high as 30-50% in actual operation which would be most beneficial to Monsanto.

FILTRASORB WASTEWATER TREATMENT PLANT DESIGN BASIS

The following design will cover two cases. Case 1 is a 200 gpm plant and Case 2 is a 600 gpm plant. It is assumed that the waste water has identical characteristics to the pilot plant in both cases. The design parameters based on the pilot plant information and corresponding assumptions for both cases are as follows:

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FILTRASORB WASTEWATER TREATMENT PLANT DESIGN BASIS (cont.)

DESIGN PARAMETER	CASE 1	CASE 2
Flow Rate ($\frac{gpm}{ppm}$)	200	600
Superficial Residence Time (minutes)	15	15
Surface Loading (gpm/ft^2)	6	6
Bed area required ($ft.^2$)	33	100
Bed depth (ft.)	12	13
Carbon exhaustion rate (lbs/day)	76	230

In both cases, the adsorption system would include the following:

An adsorber constructed of rubber or epoxy lined carbon steel. The adsorber would be equipped with a rotary surface wash and appropriate underdrain system to support the carbon. The vessels would be 50 psi pressure vessels equipped with inlet and outlet for downflow or upflow service. The upflow inlet and outlet would be required for periodic backwashing. Pumps would be required for pumping of the waste stream and pumping the backwash water against the 50 psi head. The carbon could be used on a throwaway basis whereby the exhausted carbon is discarded and replaced with virgin carbon. The carbon may also be reactivated in either a rotary kiln or Herreshoff multiple hearth with refractory linings. If reactivation is desired, a dewatering screw, quench tank, spent and reactivated carbon storage tanks, and blowcase would be included in the reactivation package. The smallest efficient reactivation facility which can be supplied has the capacity to reactivate approximately 2400 pounds/day. Thus, both systems would require this, however, it would not be in operation as often in Case 1.

FILTRASORB SYSTEM DESIGN AND COST ESTIMATES

The Filtrasorb system design and "ballpark" capital and operating cost estimates for both cases would be as follows:

DESIGN/ESTIMATE	CASE 1	CASE 2
Adsorber size	7' Dia. x 8' SS	11' Dia. x 21' SS
Carbon volume per adsorber	460 cu. ft.	1240 cu. ft.
Pounds of carbon per adsorber	12,500	33,500
Cycle Time	164 days	146 days
Cost of adrorber installed	$25,000	$45,000
Reactivation Package Cost	$74,000	$84,000

(The difference in the reactivation package costs is due to the larger storage tank required for Case 2)

The capital cost for Case 1 would be $25,000 plus or minus 30% without reactivation. This cost does not include pumps, engineering or other indirects. With reactivation, the cost for Case 1 would be $99,000 plus or minus 30% plus pumps, engineering or other indirects. The capital cost for Case 2 would be $45,000 plus or minus 30% not including pumps, engineering or other indirects without reactivation. With reactivation the capital cost would be $129,000 plus or minus 30% plus pumps, engineering or other indirects.

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FILTRASORB SYSTEM DESIGN AND COST ESTIMATES (Cont.)

The operating costs for Case 1 on a throwaway basis would be $25/day for the carbon plus the labor required to empty and refill the column every 164 days. With the reactivation furnace in Case 1, the furnace would be required to operate 5 days out of 164 in order to reactivate all the carbon in one column. Averaged out on a daily basis, the operating cost will be $4/day; this cost includes labor to empty and refill columns and startup and shutdown the reactivation furnace. The operating cost for Case 2 on a throwaway basis would be $55/day for the carbon plus labor to empty and refill the columns every 146 days. With reactivation in Case 2, the operating costs would be $17/day this includes labor for emptying and refilling the columns and starting up and shutting down the furnace. The reactivation furnace would be required to operate approximately 14 out of 146 days. The reactivation furnace would be operated for 24 hours a day automatically during the reactivation time. Labor would only be necessary at the start and finish of the reactivation cycle otherwise the furnace operates by itself.

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