BEHAVIOR OF PSAs: MOW AND SORTED OFFICE PAPER WITH HIGH CONTENT OF PSAs

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ABSTRACT

The recyclability of paper contaminated with pressure sensitive adhesives was evaluated using Western Michigan University's state-of-the-art recycling and deinking facility. The process flow system in the recycling and deinking facility was arranged based on the USPS protocol and collected samples were evaluated also based on the USPS protocol. Two experimental adhesives were evaluated in these trials. One of these adhesives formed significantly larger particles, which were more readily removed. Of the separation processes used in this trial, screening was shown to be the most effective in removing these larger particles. One of the conclusions from this study is that the ability of the adhesive to form larger particles greatly enhances its removal from the recycle stream. Final dirt counts of about 10 ppm were achieved with the pulp containing the larger particles.

INTRODUCTION

Objectives: The objective of this project was to evaluate the recyclability of paper contaminated with controlled levels of pressure sensitive adhesives (PSA). The adhesives were experimental post stamp adhesives supplied by the United States Forest Products Laboratory and designated Adhesive 33220 and Adhesive 33226.

Procedure: Samples of each of the stamp laminates #33220 and #33226 were supplied for separate recycling pilot trials. Each of these samples was separately repulped with a base tock consisting of envelope paper and copy paper. The resulting furnishes contained 45.5% envelope paper stock, 45.5% copy paper stock, and 9% stamp laminate. Based on this furnish composition, the resulting stock contained 1% PSA or 1000 ppm.

The Western Michigan Recycling Facility, shown in Figure 1, consists of a number of commercial size units that can be arranged in numerous configurations. In these trials, the individual repulped furnishes were processed through the pilot recycling system according to the supplied USPS Protocol. The units operations specified in this protocol and the sample points are shown in Figure 2.

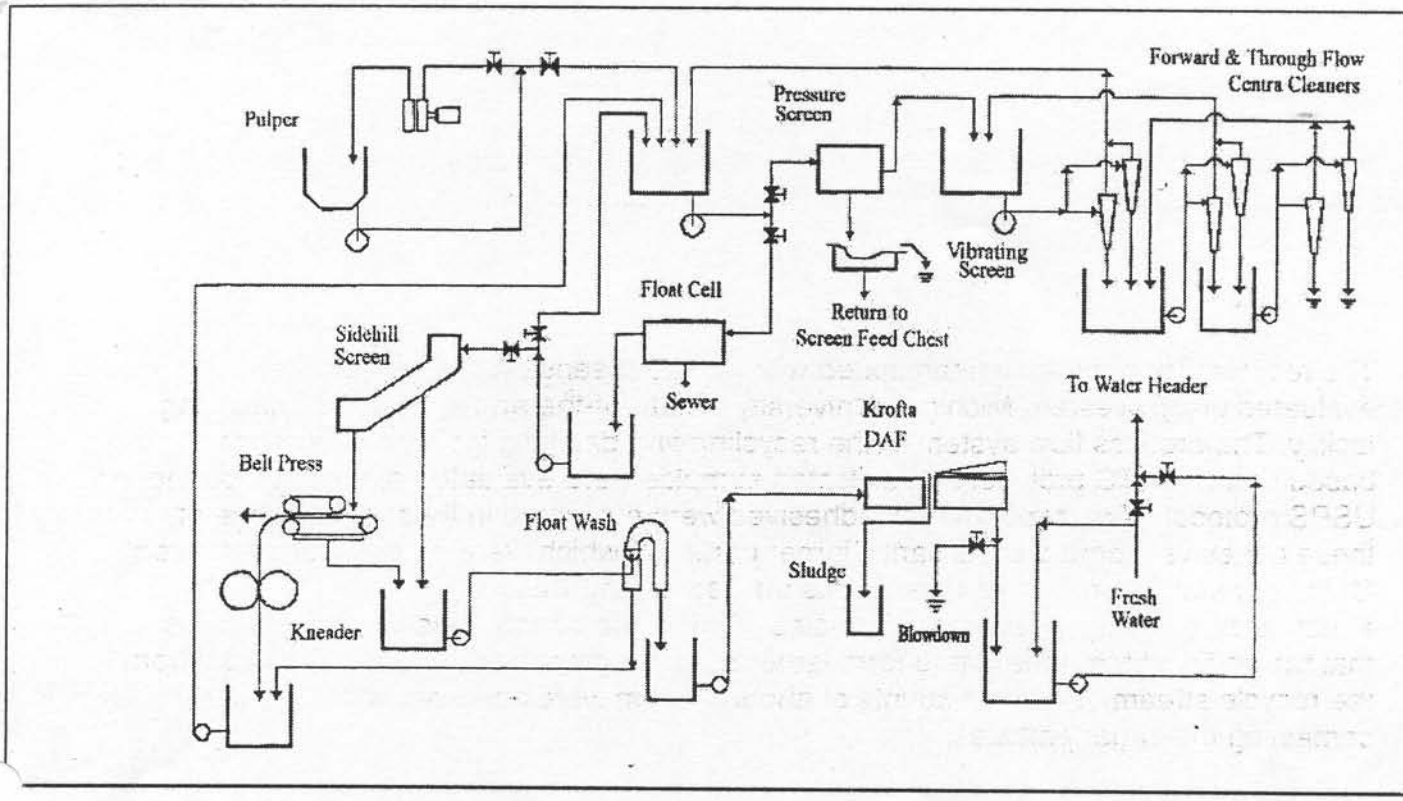

Figure 1, Western Michigan University's Recycling and Deinking Facility

The WMU Recycling and Deinking Facility contains a modular piping system that allows the connection of the individual units in any configuration to simulate a wide variety of industrial systems. The fiber recycling facility is manually controlled from the operator's panel. Data are collected by a computer, which logs all measured variables. The collected dada can be recalled and printed out in table form or graphed automatically. The system also has a remote display in the operator's control panel where real-time graphics are displayed and automatically updated every 10 seconds.

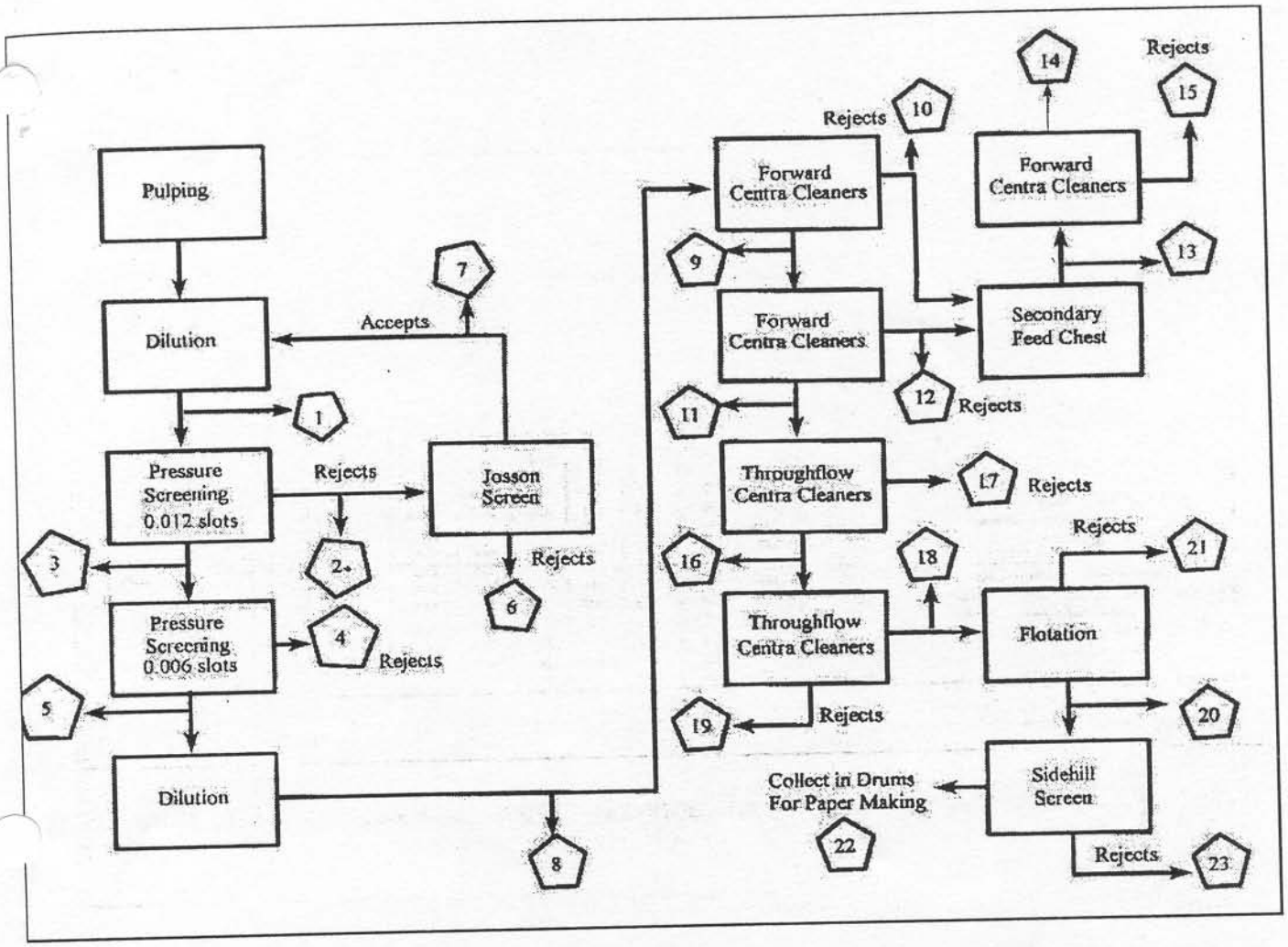

Figure 2, Western Michigan University's Recycling Facility as Arranged Based on the USPS Recycling Protocol

RESULTS

The sample points are shown as pentagons in Figure 2. Once the system reached steady state, four-gal stock-samples were collected at the designated sample points. Fifteen handsheets were produced from each of the stock samples and analyzed for total dirt and adhesive using the USPS protocol. This protocol was based on an image analysis for dirt specks before and after adhesive staining. The difference between these measurements is then the adhesive dirt count. This data is presented in the following tables. Table 1 shows the dirt count at the individual sample points before staining, Table 2 shows the dirt count after staining and Table 3 shows the dirt count difference between before and after staining. This procedure of measuring adhesives through a difference measurement was required since the stock contained some printed material.

Table 1, Pre-stained Dirt Analysis

Sample ID	Location	Consistency (%)	Pre Stained Handsheets Image Analysis											
			Number of Specks		Total Area (sq.mm)		PPM		StdDev of Sheet PPM		Count in 1 sq.m		Counting Precision	
			All Sizes	>=0.040	All Sizes	>=0.040	All Sizes	>=0.040	All Sizes	>=0.040	All Sizes	>=0.040	All Sizes	>=0.040
Trial 1	Adhesive #33220													
1-1	Pressure Screen Feed 0.062 Screen	1.75	169	60	10.58	7.59	53.2	38.1	31.79	31.12	849	301	7.69	12.91
1-3	Pressure Screen Accepts 0.062 Screen	1.71	136	38	6.62	3.92	33.3	19.7	20.39	21.28	683	191	8.57	16.22
1-5	Pressure Screen Accepts 0.006 Screen	1.29	115	42	6.70	4.71	33.7	23.6	31.60	30.74	578	211	9.33	15.43
1-7	Johnson Screen Accepts	2.20	135	54	10.07	7.82	50.6	39.3	46.58	47.67	678	271	8.61	13.61
1-9	Forward Centra Cleaner Accepts, 1st Pass	0.68	100	21	4.00	1.85	20.1	9.3	12.91	10.15	502	105	10.00	21.81
1-11	Forward Centra Cleaner Accepts, 2nd Pass	0.62	102	38	10.20	8.40	51.2	42.2	108.41	106.98	512	191	9.90	16.22
1-14	Secondary Forward Cleaner Accepts	1.23	283	95	13.47	8.23	67.7	41.4	26.79	27.78	1421	477	5.94	10.26
1-16	Throughflow Centra Cleaner Accepts Pass #1	0.65	81	30	4.14	2.74	20.8	13.8	15.19	13.13	407	151	11.11	18.26
1-18	Throughflow Centra Cleaner Accepts Pass #2	0.69	94	26	5.57	3.68	28.0	18.5	42.55	42.58	472	131	10.31	19.61
1-20	Flotation Cell Accepts	0.70	124	45	5.92	3.82	29.7	19.2	16.45	14.80	623	226	8.98	14.91
1-22	Pressed Thick Stock	30.00	172	73	11.16	8.44	21.0	15.9	18.91	19.08	324	137	7.62	11.70
Trial 2	Adhesive #33226													
2-1	Pressure Screen Feed 0.014 Screen	1.80	232	62	9.45	4.73	47.5	23.8	17.05	15.99	1165	311	6.57	12.70
2-3	Pressure Screen Accepts 0.014 Screen	1.45	264	66	10.68	5.35	53.7	26.9	24.56	23.73	1326	331	6.15	12.31
2-5	Pressure Screen Accepts 0.006 Screen	1.15	227	50	9.71	4.79	48.8	24.1	22.83	21.66	1140	251	6.64	14.14
2-7	Johnson Screen Accepts	2.94	130	48	7.60	5.37	38.2	27.0	25.92	24.83	653	241	8.77	14.43
2-9	Forward Centra Screen Accepts, 1st Pass	0.59	226	56	9.18	4.57	46.1	22.9	23.22	19.39	1135	281	6.65	13.36
2-11	Forward Centra Screen Accepts, 2nd Pass	0.54	103	36	5.58	3.81	28.0	19.1	22.50	22.14	517	181	9.85	16.67
2-14	Secondary Forward Centra Cleaner Accepts	2.20	740	217	33.72	19.50	169.4	97.9	52.13	49.87	3717	1090	3.68	6.79
2-16	Throughflow Centra Cleaner Accepts Pass #1	3.20	71	18	3.72	2.25	18.7	11.3	19.60	18.41	357	90	11.87	23.57
2-18	Throughflow Centra Cleaner Accepts Pass #2	0.58	106	24	16.72	14.54	84.0	73.0	207.12	206.00	532	121	9.71	20.41
2-20	Flotation Cell Accepts	0.57	111	38	5.67	3.67	28.5	18.4	21.61	20.11	558	191	9.49	16.22
2-22	Pressed Thick Stock	30.00	218	69	12.77	8.53	24.0	16.1	17.82	17.50	411	130	6.77	12.04

After staining the handsheets were again analyzed for dirt and these results are shown in Table 2.

Table 2, Post-stained Dirt Analysis

Sample ID	Location	Post Stained Handsheets Image Analysis											
		Number of Specks		Total Area (sq.mm)		PPM		StdDev of Sheet PPM		Count in 1 sq.m		Counting Precision	
		All Sizes	>=0.040	All Sizes	>=0.040	All Sizes	>=0.040	All Sizes	>=0.040	All Sizes	>=0.040	All Sizes	>=0.040
Trial 1	Adhesive #33220												
1-1	Pressure Screen Feed 0.062 Screen	305	159	144.05	140.06	723.5	703.4	616.80	616.38	1532	799	5.73	7.93
1-3	Pressure Screen Accepts 0.062 Screen	208	103	43.75	40.92	219.7	205.5	344.28	343.32	1045	517	6.93	9.85
1-5	Pressure Screen Accepts 0.006 Screen	169	78	16.73	14.18	84.0	71.2	54.91	51.91	849	392	7.69	11.32
1-7	Johnson Screen Accepts	353	219	399.93	396.10	2008.7	1989.5	1061.34	1059.30	1773	1100	5.32	6.76
1-9	Forward Centra Cleaner Accepts, 1st Pass	128	49	11.44	9.16	57.4	46.0	50.35	49.75	643	246	8.84	14.29
1-11	Forward Centra Cleaner Accepts, 2nd Pass	157	77	16.13	13.80	81.0	69.3	72.17	72.23	789	387	7.98	11.40
1-14	Secondary Forward Cleaner Accepts	337	112	21.60	15.36	108.5	77.2	36.54	39.58	1693	563	5.45	9.45
1-16	Throughflow Centra Cleaner Accepts Pass #1	119	46	7.18	5.03	36.0	25.3	17.51	17.24	598	231	9.17	17.74
1-18	Throughflow Centra Cleaner Accepts Pass #2	104	31	4.69	2.70	23.6	13.5	16.75	16.70	522	156	9.81	17.96
1-20	Flotation Cell Accepts	104	37	4.85	2.97	24.4	14.9	13.67	12.08	522	186	9.81	16.44
1-22	Pressed Thick Stock	261	100	17.24	12.71	32.5	23.9	25.58	24.93	492	188	6.19	10.00
Trial 2	Adhesive #33226												
2-1	Pressure Screen Feed 0.014 Screen	4552	3578	907.10	878.60	4556.0	4412.9	747.01	728.24	22863	17971	1.48	1.67
2-3	Pressure Screen Accepts 0.014 Screen	4891	3743	808.42	775.02	4060.4	3892.6	500.24	487.73	24566	18800	1.43	1.63
2-5	Pressure Screen Accepts 0.006 Screen	2670	2030	497.78	479.32	2500.2	2407.4	493.02	490.81	13410	10196	1.94	2.22
2-7	Johnson Screen Accepts	6188	5212	1797.87	1769.34	9030.0	8886.7	1344.05	1321.19	31080	26178	1.27	1.39
2-9	Forward Centra Screen Accepts, 1st Pass	1768	1317	416.93	403.86	2094.1	2028.4	724.30	720.82	8880	6615	2.38	2.76
2-11	Forward Centra Screen Accepts, 2nd Pass	505	366	125.57	121.63	630.7	610.9	279.39	278.99	2536	1838	4.45	5.23
2-14	Secondary Forward Centra Cleaner Accepts	5455	4383	2177.31	2147.05	10935.8	10783.8	869.65	873.05	27398	22014	1.35	1.51
2-16	Throughflow Centra Cleaner Accepts Pass #1	255	172	72.13	69.77	362.3	350.4	171.75	170.23	1281	864	6.26	7.62
2-18	Throughflow Centra Cleaner Accepts Pass #2	349	218	120.42	116.80	604.8	586.6	264.73	263.34	1753	1095	5.35	6.77
2-20	Flotation Cell Accepts	173	93	31.48	29.24	158.1	146.9	123.03	121.10	869	467	7.60	10.37
2-22	Pressed Thick Stock	1020	775	349.91	342.94	639.1	645.9	263.80	263.42	1921	1460	3.13	3.59

To determine the level of adhesive in the samples, the prestained readings were ›tracted from the post-stained. The difference of these readings is then referred to as the Delta Analysis and is shown in Table 3.

Table 3, Delta Dirt Analysis

Sample ID	Location	Delta Dirt Count (Post Stained - Pre Stained)							
		Number of Specks		Total Area (sq.mm)		PPM		Count in 1 sq.m	
		All Sizes	>=0.040	All Sizes	>=0.040	All Sizes	>=0.040	All Sizes	>=0.040
Trial 1	Adhesive #33220								
1-1	Pressure Screen Feed 0.062 Screen	136	99	133.47	132.47	670.3	665.3	683	498
1-3	Pressure Screen Accepts 0.062 Screen	72	65	37.13	37.00	186.4	185.8	362	326
1-5	Pressure Screen Accepts 0.006 Screen	54	36	10.03	9.47	50.3	47.6	271	181
1-7	Johnson Screen Accepts	218	165	389.86	388.28	1958.1	1950.2	1095	829
1-9	Forward Centra Cleaner Accepts, 1st Pass	28	28	7.44	7.31	37.3	36.7	141	141
1-11	Forward Centra Cleaner Accepts, 2nd Pass	55	39	5.93	5.40	29.8	27.1	277	196
1-14	Secondary Forward Cleaner Accepts	54	17	8.13	7.13	40.8	35.8	272	86
1-16	Throughflow Centra Cleaner Accepts Pass #1	38	16	3.04	2.29	15.2	11.5	191	80
1-18	Throughflow Centra Cleaner Accepts Pass #2	10	5	-0.88	-0.98	-4.4	-5.0	50	25
1-20	Flotation Cell Accepts	-20	-8	-1.07	-0.85	-5.3	-4.3	-101	-40
1-22	Pressed Thick Stock	89	27	6.08	4.27	11.5	8.0	168	51
Trial 2	Adhesive #33226								
2-1	Pressure Screen Feed 0.014 Screen	4320	3516	897.55	873.87	4508.5	4389.1	21698	17660
2-3	Pressure Screen Accepts 0.014 Screen	4627	3677	797.74	769.67	4006.7	3865.7	23240	18469
2-5	Pressure Screen Accepts 0.006 Screen	2443	1980	488.07	474.53	2451.4	2383.3	12270	9945
2-7	Johnson Screen Accepts	6058	5164	1790.27	1763.97	8991.8	8859.7	30427	25937
2-9	Forward Centra Screen Accepts, 1st Pass	1542	1261	407.75	399.29	2048.0	2005.5	7745	6334
2-11	Forward Centra Screen Accepts, 2nd Pass	402	330	119.99	117.82	602.7	591.8	2019	1657
2-14	Secondary Forward Centra Cleaner Accepts	4715	4166	2143.59	2127.55	10766.4	10685.9	23681	20924
2-16	Throughflow Centra Cleaner Accepts Pass #1	184	154	68.41	67.52	343.6	339.1	924	774
2-18	Throughflow Centra Cleaner Accepts Pass #2	243	194	103.70	102.26	520.8	513.6	1221	974
2-20	Flotation Cell Accepts	62	55	25.81	25.57	129.6	128.5	311	276
2-22	Pressed Thick Stock	802	706	337.14	334.41	635.1	629.8	1510	1330

The above tables show that the adhesives can be removed in the recycling system. It is interesting to note that adhesive #33220 is more readily removed than adhesive #33226. This is believed to be due to its larger particle size.

To show where the dirt and adhesives are removed, the Post-Strained dirt levels are shown versus location in Figures 3 and 4. Figure 3 shows dirt level versus location for the smaller #33226 adhesive and Figure 4 sows dirt level location for the larger #33220 adhesive.

The nomenclature used in these figures is Pressure Screen Feed (PSF), Pressure Screen Accepts (PSA), Forward Centra Cleaner Accepts (FCCA), Through-flow Centra Cleaner (TFCC), Floatation Cell Accepts (FCA), and Pressed Thick Stock (PTS).

DISCUSSION and CONCLUSSIONS

The most important of the contaminant parameters in separating the contaminants from pulp is particle size. Although particle shape and specific gravity also play a role in separation, particle size is the more important parameter for separation. Larger particles relative to paper fibers are readily removed with a minimum loss of fiber. Of the three basis separation processes employed (filtration, sedimentation and flotation, and screening), screening is the most efficient if the material to be removed is larger than the paper fibers.

After repulping under similar conditions, the initial contaminants from adhesive 33220 were larger and fewer than those from the #33226 adhesive. The fewer and larger particles generated form adhesive #33220 were removed form the stock slurry by the 0.062 screen and the 0.006 screen to a much larger extent than the 0.014 screen and the 0.006 screen used with the #33226 adhesive. This can be seen in comparing figures 3 and 4. The separation processes were more efficient in removing the larger particles at equal flow rates, pressures and reject rates. With the larger particles, the separation processes appeared to be quite efficient with final contaminant levels of near 10 ppm for total contaminants (post-stained dirt analysis) and near zero for the Delta analysis.

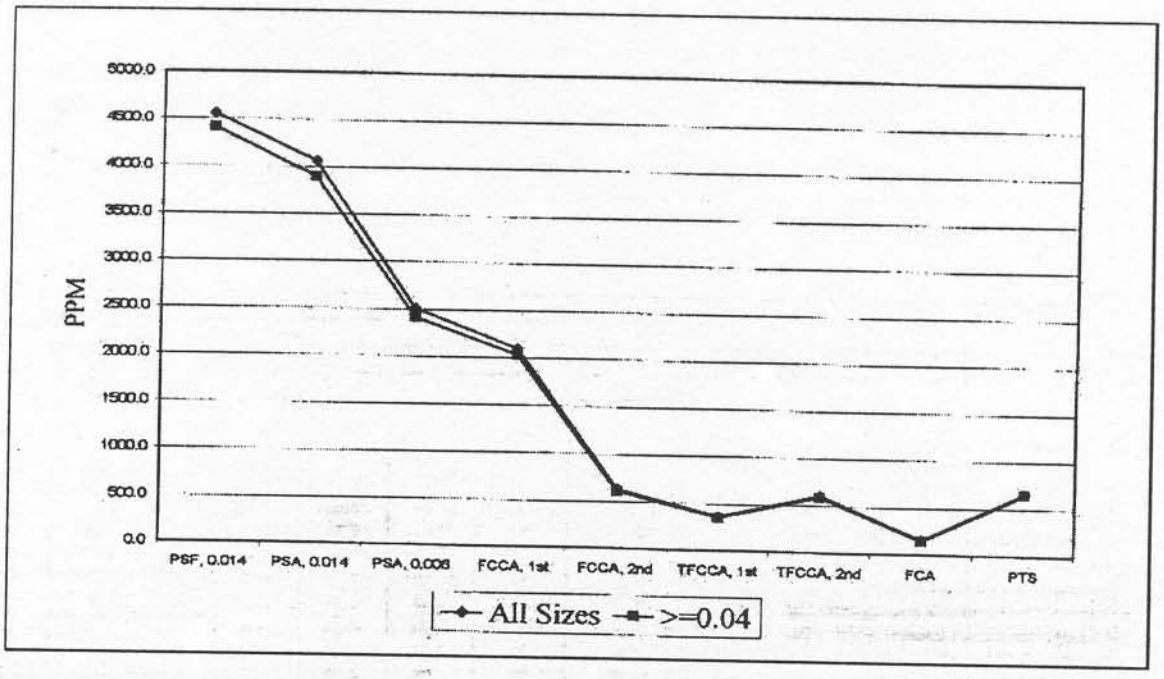

Figure 3, Dirt Level versus Location in Recycle System for Smaller Particle Size Adhesive #33226

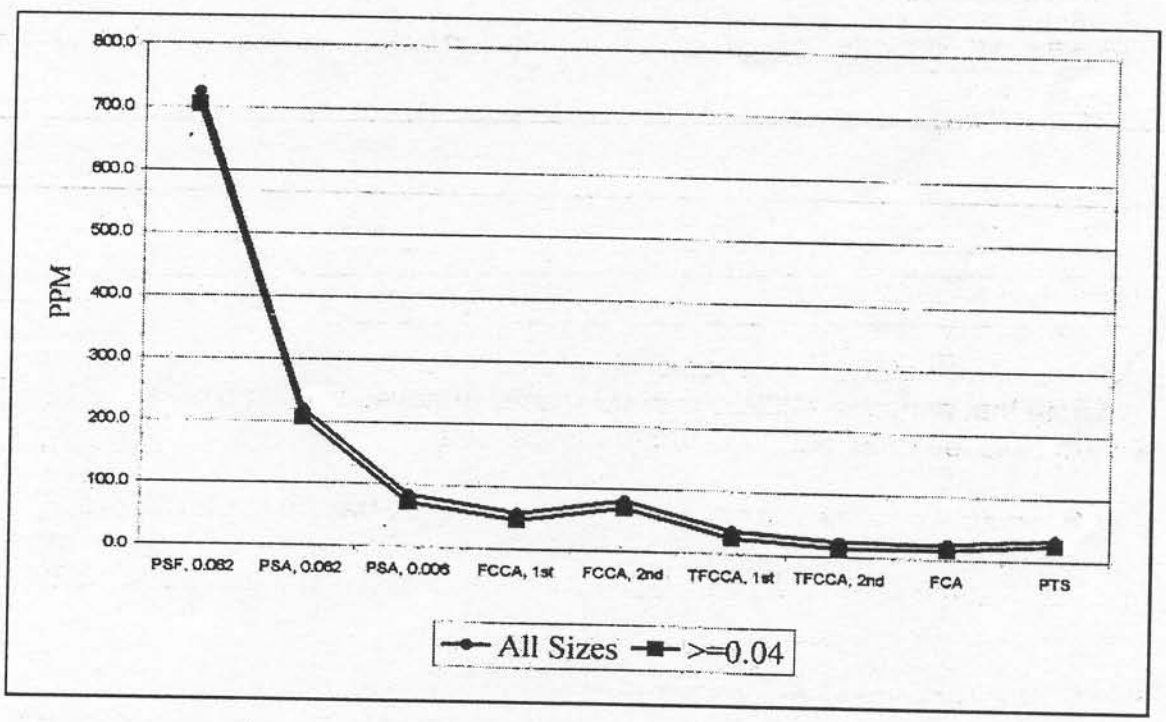

Figure 4, Dirt Level versus Location in Recycle System for Larger Particle Size Adhesive #33220