

IN-DEPTH SURVEY REPORT:
**CONTROL TECHNOLOGY FOR AGRICULTURAL ENVIRONMENTAL
ENCLOSURES**

AT

JOHN DEERE MANUFACTURING CO., INC.

REPORT WRITTEN BY
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Public Health Service
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National Institute for Occupational Safety and Health
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PLANT SURVEYED

John Deere Product Engineering
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SURVEY DATE

April 15-19, 1996 (Laboratory
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INTRODUCTION

Agriculture is one of our Nation's most dangerous occupations. Agricultural workers and their families experience a disproportionate share of injuries and diseases associated with numerous chemical, biological, and physical hazards ⁽¹⁾. Some of these diseases include asthma, hypersensitivity pneumonitis, chronic and acute bronchitis, and organic dust toxic syndrome.

This study was conducted to provide information on the effectiveness of agricultural cabs designed to protect workers from pesticides and other agriculture air contaminants and identify improvements to enhance the enclosure's efficacy. Survey reports will be distributed to various agencies and persons according to standard procedures in 41 CFR 85a and will be available from National Technical Information Service (NTIS).

STUDY OBJECTIVES

The main goal of the agricultural enclosures project is to evaluate the ability of enclosures on agricultural vehicles to reduce operator exposure to pesticides and other agriculture air contaminants. The major objectives for the laboratory and field evaluation were to

- evaluate the effectiveness of the filter system
- identify aerosol size distribution inside and outside the enclosure
- evaluate air infiltration into the cab by identifying potential leak sources
- evaluate the protection factor provided by agricultural cabs (outside concentration / inside concentration)

CAB DESIGN

See Figure 1 and 2 for air flow diagrams into the cab ^(2,3). The laboratory and field evaluation were performed on a John Deere 7000 series tractor cab equipped with a High Efficiency Particulate Air filter (HEPA filters are designed to be at least 99.97% efficient at filtering aerosols of size 0.3 μm) inside the fresh air filter housing. The cab was equipped with the standard recirculation filters inside the cab. Fresh air enters the ventilation system from the front top portion of the cab above the door. The fresh air flows through ventilation ducts over the cab and down through the front right side structure beam (part of the Roll Over Protection System (ROPS)) into the fresh air filter housing located beneath the right side of the cab. The fresh air is then pulled through the fresh air blower and transported through ventilation ducts to the evaporator/heater core housing. At this point the fresh air and recirculated air is pulled through the recirculation blower and transported to the outlet louvers inside the cab.

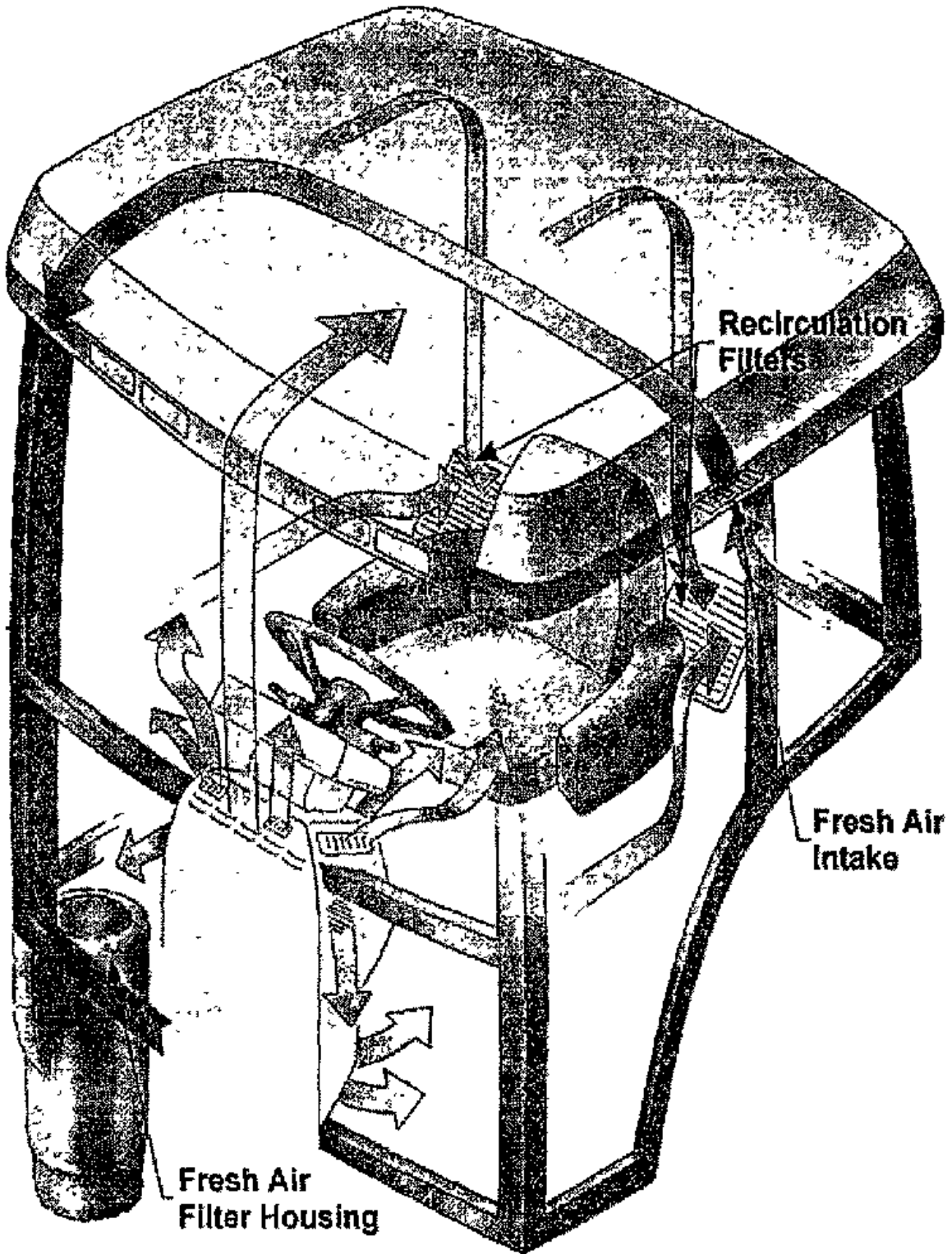


Figure 1. Diagram of air flow inside cab.⁽²⁾

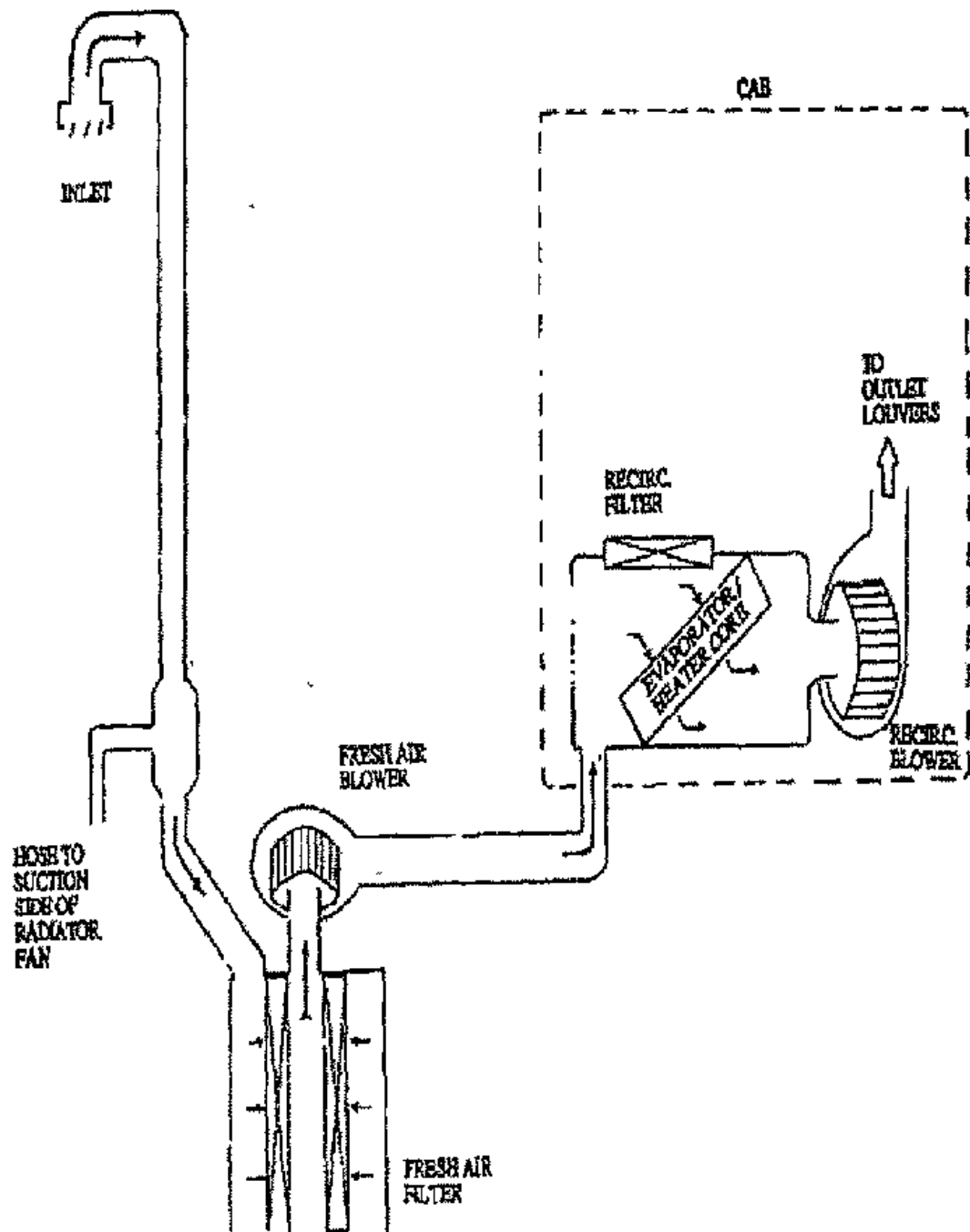


Figure 2. Air flow diagram of ventilation system.⁽³⁾

METHODS

Preliminary surveys were conducted on three different manufactured agriculture enclosures. Two of these enclosures (made by two different manufacturers) have been approved for respiratory protection in the state of California. The results obtained during the preliminary surveys identified the need for both a laboratory and field evaluation of an environmental enclosure to help identify any potential aerosol leaks into the cab. The laboratory and field evaluations were performed on a John Deere 7000 series tractor cab. Measurements taken inside and outside of the cab were collected while the tractor was stationary during the laboratory evaluation (located at the John Deere Product Engineering Center, Waterloo, IA) and while the tractor was driven over a tilled field during the field evaluation (field evaluation was conducted in Yuba City, CA). The tractor was driven over the tilled field in an effort to assess how well the cab remains sealed and its ability to remove particulate in field conditions.

The following instrumentation was used to measure the concentration of ambient aerosol outside and inside of the cab:

1. Hand-held Particle Counter (Model 227b, Met-One Inc, Grants Pass, OR) counts the number of individual particles larger than $0.3 \mu\text{m}$. The Hand-held Particle Counter (HPC) was used with a sampling rate of 2.8 liters per minute (lpm), a sampling period of 14 seconds, and a time between sampling periods of 1 second. Two channels were used to store the number of particle counts in a time interval. One channel stored the total number of particles counted greater than $0.3 \mu\text{m}$. The second channel stored the total number of particles larger than $3.0 \mu\text{m}$. This instrument sizes the particles based upon the amount of light scattered by individual particles.⁽⁴⁾
2. Portable Dust Monitor (Model 1105 and 1106, Grimm Labor Technik GmbH & CoKg, Ainning, Germany) counts the individual number of particles in eight size channels between $0.7 - 15 \mu\text{m}$ (model 1105 used during the laboratory evaluation) and $0.3 - 6.5 \mu\text{m}$ (model 1106 used during the field evaluation). Particles are sized based upon the amount of light scattered by individual particles. The Portable Dust Monitor (PDM) operates at a flow rate of 1.2 lpm.⁽⁵⁾
3. PortaCount® Plus (Model 8020, TSI Incorporated, St. Paul, MN) was used to measure ambient particle concentration inside and outside of the enclosure. The ratio of the two measurements was used to calculate a protection factor. Particles enter the PortaCount® Plus through a saturator tube where they are combined with alcohol vapor. The particles then pass through a condenser where the alcohol condenses on the particles, which increases the particle size. The enlarged particles then pass through a laser beam that produces flashes of light that are detected by a photodetector. Particle concentrations are determined by the amount of light flashes. The PortaCount® Plus counts particles in a range of 0.02 to greater than $1 \mu\text{m}$ with a flow rate of 0.1 lpm (TSI Incorporated, St. Paul, MN).⁽⁶⁾

The PortaCount® Plus was used to measure leakage of particles (in the range of 0.02 - 1.0 µm) into the cab during both evaluations. Condensation nuclei was measured in the ambient air outside the cab and inside the cab. The PortaCount® Plus is equipped with two sampling probes. One sampling probe was used to collect aerosol concentrations inside the cab and the other sampling probe was used to collect ambient aerosol concentrations outside the cab. This test was performed in an effort to evaluate the protection factor of the cab during both lab and field conditions.

The PortaCount® Plus collected twelve separate samples during each field test run. Four separate field test runs were completed. Each of the twelve separate samples (obtained during a field test run) were collected over a 60 second period. A protection factor (ratio between particle concentrations outside and inside the enclosure) was calculated for each sample. A low protection factor is an indicator of particle leakage into the cab or an indicator of particle generation sources inside the cab.

During both evaluations, one HPC and PDM were placed inside the tractor cab to count particles. These instruments were used to evaluate the enclosure's overall ability to protect the worker from aerosol exposure. Another HPC and PDM were placed directly outside the cab near the air intake. During the evaluations, the instruments were switched to obtain additional readings. The instruments located inside the cab were placed outside, and the instruments located outside the cab were placed inside. The HPCs and PDMs were run for approximately 30 minutes and then switched. This process was repeated 4 times, both to collect enough data for analysis and to limit the effect of instrument bias.

Data Analysis and Evaluation

All data collected from the HPC and PDM were downloaded into a portable computer and placed in a spreadsheet for analysis. Penetration of different size aerosols, efficiency of the filter system, and protection factors were determined by comparing data collected (with the HPC and PDM) inside the enclosure with data collected directly outside the enclosure.

Ventilation Measurements

The air velocity into the fresh air inlet was measured with a velometer. An autozero digital micromanometer, MP series 4 (Solomat, a Neotronics company, Norwalk, CT), was used during the evaluations to measure air pressure inside the cab. A metrosomic dl-3200 data logger (Metrosomic Inc., Rochester, NY) was used to record the data output of the digital micromanometer throughout both evaluations. During the laboratory evaluation the ventilation system was run off a battery charger since the tractor was not started inside the building. Ventilation measurements during the field evaluation were collected while the tractor was running.

RESULTS

Laboratory Evaluation

The HPC raw particle counts for the laboratory evaluation are listed in Appendix A. The HPC counts naturally occurring ambient particles in the size range of 0.3 - 3.0 μm and particles greater than 3.0 μm . The HPC results during the laboratory evaluation indicate that the filter system in the cab was 99% efficient at removing particles in the size range between 0.3 and 3.0 μm with a mean protection factor (outside concentration/inside concentration) of 86 in this size range. The HPC results also indicated that the ventilation system in the cab was 99% efficient at removing particles larger than 3.0 μm with a mean protection factor of 80 in this size range. The PDM raw particle counts for the laboratory study are listed in Appendix B. Table 1 gives the protection factor and efficiency for each particle size range counted by the PDM. The PDM used in the laboratory study (model 1105) counted aerosols in eight different size ranges (0.7 - 15 μm). PDM results indicated that the ventilation system on the cab was 99% efficient at removing particles larger than 0.7 μm . The PDM results were also used to calculate protection factors. Protection factors ranged from 112 - 275 (outside/inside concentration).

Table 1. Filtration Efficiency and Protection Factors by particle size as shown by the PDM (model 1105).

Particle Size (μm)	0.7 - 1	1 - 2	2 - 3.5	3.5 - 5	5 - 7.5	7.5 - 10	10 - 15
Efficiency of Cab	99%	99%	99%	99%	99%	99%	99%
Protection Factor (outside/inside)	200	198	112	147	214	275	123

The PortaCount® Plus counts particles smaller than 1 μm and was used during the laboratory evaluation to calculate a protection factor for the cab. The mean protection factor (obtained with the PortaCount® Plus) during the laboratory evaluation was 38 for particles smaller than 1 μm .

Field Test Evaluation

The field evaluation was conducted in Yuba City, CA. The tractor was driven over a tilled field in an effort to assess how well it remains sealed and its ability to remove particulate in field conditions.

The HPC raw particle counts for the field evaluation are listed in Appendix C. Results of the HPC are summarized in Figure 3. The HPC results during the field evaluation indicate that the filter system in the cab was 96% efficient at removing particles in the size range between 0.3 and 3.0 μm with a mean protection factor (outside concentration/inside concentration) of 28 in this particle range. The HPC results also indicated that the ventilation system in the cab was 99% efficient at removing particles larger than 3.0 μm with a mean protection factor of 460 in this size range.

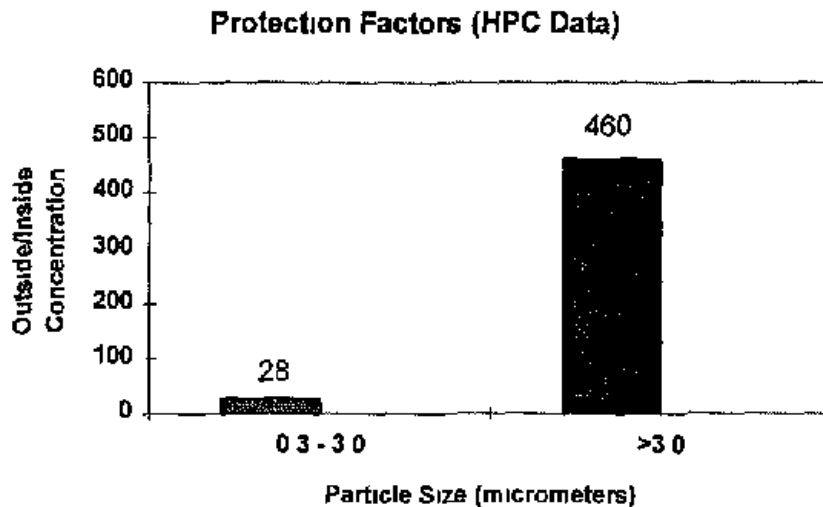


Figure 3. HPC Data Protection Factors

The PDM raw particle counts for the field study are listed in Appendix D. The PDM used in the field study (model 1106) counted aerosols in eight different size ranges from 0.4 to 6.5 μm . The filtration efficiency of the cab and protection factor at each different size range measured by the PDM are listed in Table 2. Protection factors ranged from 32 - 4000 (outside/inside concentration).

Table 2. Filtration Efficiency and Protection Factors by particle size as shown by the PDM (model 1106).

Particle Size (μm)	0.42	0.61	0.87	1.41	2.65	4.18	5.7	6.5
Efficiency of Cab	99%	98%	97%	99%	99%	99%	99%	99%
Protection Factor (outside/inside)	84	41	32	130	260	1100	2200	4000

The PortaCount® Plus was used during the field evaluation to calculate the cab's protection factor for particles < 1 µm. The mean protection factor (obtained with the PortaCount® Plus) during the field evaluation was 43 (outside/inside concentration for particles < 1 µm). The PortaCount® Plus results confirmed the data collected with the HPC and PDM. As indicated by the HPC and PDM, the filtration system on the cab provided lower protection factors for smaller particles.

Ventilation measurements were taken at the top right corner of the cab where the fresh air flows through the opening of the structure beam (part of the ROPS system). The area of the opening is 0.35 square feet. During the laboratory evaluation the average air velocity entering this opening was 1700 fpm which resulted in an air volume of 600 cfm. During the field evaluation ventilation measurements were collected at the same location. The average air velocity during the field evaluation was 2000 fpm which resulted in an air volume of 700 cfm. Pressure measurements inside the cab were also collected during both evaluations with an autozero digital micromanometer. The data output of the micromanometer was recorded with a data logger. The pressure remained positive inside the cab during both evaluations with a mean pressure reading of 0.78 inches of water during the laboratory evaluation (tractor was running when pressure measurements were obtained), and 0.75 inches of water during the field evaluation.

CONCLUSIONS

The HPC and the PDM both indicated that the cab is more than 99% efficient at removing aerosols larger than 3.0 µm in diameter. PDM results indicate that protection factors are greater than 100 (outside/inside concentration) for particles larger than 1.41 µm during the field evaluation. During the laboratory evaluation protection factors were greater than 100 for particles larger than 0.75 µm. The results obtained with the PortaCount® Plus indicate that the cab provided a mean protection factor of 38 (during laboratory evaluation) and 43 (during field evaluation) for aerosols smaller than 1.0 µm in diameter. As the particle size decreases (< 1 µm), the efficiency of the cab starts to decrease and protection factors are less than 100 (see Table 1). This indicates that there may be some leakage of small particles into the cab.

The pressure measurements collected inside the cab indicated that the cab remained under positive pressure during both our evaluations at approximately 0.75 inches of water. The positive pressure inside the cab reduces the possibility of aerosols entering the cab through leak sources other than around the filters and seals in the ventilation system. Therefore, any leakage of small particles (<2 µm) into the cab may be a result of these small particles penetrating around the seals used to hold the filters in place in the ventilation system. There is also a possibility that some of the small aerosols (inside the cab) could be generated by the blowers or generated from the operator movement inside the cab.

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- 6 TSI [1993] PortaCount®Plus Model 8020, Operation and Service Manual, Rev C, TSI Incorporated, St Paul, MN

APPENDIX A

LABORATORY EVALUATION					
	Par/cc 0 3-3 0	Par/cc 0 3-3 0		Par/cc>3 0	Par/cc>3 0
Time	(inside)	(outside)	Time	(inside)	(outside)
0 00	6 44	252 17	0 00	0 02	0 19
14 00	6 43	255 05	14 00	0 01	0 19
28 00	6 22	257 53	28 00	0 00	0 16
42 00	6 00	261 87	42 00	0 01	0 14
56 00	5 78	265 83	56 00	0 00	0 13
70 00	5 88	266 40	70 00	0 00	0 13
84 00	5 59	266 46	84 00	0 00	0 10
98 00	5 90	265 55	98 00	0 00	0 11
112 00	5 63	265 71	112 00	0 00	0 09
126 00	5 58	266 59	126 00	0 00	0 10
140 00	5 89	271 56	140 00	0 00	0 11
154 00	5 70	273 96	154 00	0 02	0 12
168 00	5 77	271 20	168 00	0 00	0 09
182 00	5 87	264 35	182 00	0 00	0 10
196 00	6 13	267 54	196 00	0 00	0 11
210 00	5 97	267 12	210 00	0 00	0 11
224 00	6 15	267 49	224 00	0 00	0 11
238 00	6 16	271 35	238 00	0 00	0 12
252 00	6 36	268 74	252 00	0 00	0 13
266 00	6 06	269 80	266 00	0 00	0 11
280 00	6 34	270 23	280 00	0 00	0 09
294 00	6 77	270 42	294 00	0 00	0 14
308 00	6 93	270 62	308 00	0 00	0 11
322 00	6 90	266 87	322 00	0 00	0 11
336 00	7 02	265 15	336 00	0 00	0 10
350 00	6 77	270 46	350 00	0 00	0 12
364 00	6 87	269 80	364 00	0 00	0 11
378 00	6 53	270 14	378 00	0 00	0 10
392 00	6 76	273 40	392 00	0 00	0 10
406 00	6 72	276 00	406 00	0 00	0 11
420 00	6 33	275 69	420 00	0 00	0 11
434 00	6 17	274 56	434 00	0 00	0 11
448 00	6 62	273 12	448 00	0 00	0 09
462 00	6 53	269 67	462 00	0 00	0 08
476 00	6 55	270 28	476 00	0 00	0 10
490 00	6 63	270 12	490 00	0 00	0 10
504 00	6 60	269 49	504 00	0 00	0 09
518 00	6 42	266 91	518 00	0 00	0 11
532 00	6 66	268 26	532 00	0 00	0 10
546 00	6 31	267 36	546 00	0 00	0 11
560 00	6 44	271 37	560 00	0 00	0 13
574 00	6 28	272 59	574 00	0 00	0 11

588 00	6 43	272 90	588 00	0 00	0 12
602 00	6 52	275 55	602 00	0 00	0 10
616 00	6 56	278 03	616 00	0 00	0 10
630 00	7 11	275 82	630 00	0 00	0 12
644 00	6 90	272 26	644 00	0 00	0 16
658 00	6 64	268 14	658 00	0 00	0 11
672 00	6 56	268 54	672 00	0 00	0 11
686 00	6 66	267 71	686 00	0 00	0 10
700 00	6 37	264 59	700 00	0 00	0 11
714 00	6 25	266 09	714 00	0 00	0 11
728 00	6 03	267 08	728 00	0 00	0 11
742 00	6 10	266 39	742 00	0 00	0 11
756 00	6 03	268 48	756 00	0 00	0 09
770 00	6 14	268 08	770 00	0 00	0 11
784 00	6 11	267 96	784 00	0 00	0 10
798 00	6 21	266 55	798 00	0 00	0 07
812 00	6 04	263 93	812 00	0 00	0 13
826 00	6 05	268 18	826 00	0 00	0 15
840 00	5 98	265 12	840 00	0 00	0 13
854 00	5 86	268 07	854 00	0 00	0 14
868 00	6 16	271 12	868 00	0 00	0 15
882 00	5 98	272 25	882 00	0 00	0 14
896 00	6 18	270 32	896 00	0 00	0 11
910 00	6 14	270 86	910 00	0 00	0 13
924 00	5 84	267 96	924 00	0 00	0 13
938 00	5 96	266 39	938 00	0 01	0 15
952 00	6 10	268 17	952 00	0 01	0 17
966 00	5 92	267 12	966 00	0 00	0 13
980 00	6 05	267 42	980 00	0 00	0 13
994 00	5 90	268 01	994 00	0 00	0 16
1008 00	5 90	264 75	1008 00	0 00	0 23
1022 00	5 74	268 39	1022 00	0 01	0 24
1036 00	5 76	269 35	1036 00	0 00	0 25
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1064 00	5 78	269 37	1064 00	0 00	0 17
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1092 00	6 16	267 15	1092 00	0 00	0 15
1106 00	5 81	265 16	1106 00	0 00	0 18
1120 00	5 92	263 59	1120 00	0 00	0 15
1134 00	5 69	265 34	1134 00	0 00	0 17
1148 00	5 99	266 73	1148 00	0 01	0 17
1162 00	5 95	262 66	1162 00	0 00	0 16
1176 00	5 74	258 24	1176 00	0 00	0 15
1190 00	5 75	260 03	1190 00	0 01	0 19
1204 00	5 86	264 35	1204 00	0 00	0 13
1218 00	5 79	264 38	1218 00	0 00	0 10
1232 00	5 86	268 90	1232 00	0 01	0 16
1246 00	5 25	265 10	1246 00	0 00	0 16
1260 00	5 62	263 42	1260 00	0 00	0 17

1274 00	5 63	262 88	1274 00	0 00	0 13		
1288 00	5 79	262 09	1288 00	0 00	0 11		
1302 00	6 23	259 18	1302 00	0 00	0 14		
1316 00	6 15	264 26	1316 00	0 00	0 17		
1330 00	5 85	266 39	1330 00	0 00	0 14		
1344 00	6 66	262 02	1344 00	0 00	0 13		
1358 00	6 49	260 66	1358 00	0 00	0 16		
1372 00	6 59	264 51	1372 00	0 00	0 12		
1386 00	6 06	264 51	1386 00	0 00	0 12		
1400 00	6 67	263 94	1400 00	0 00	0 21		
1414 00	6 45	260 57	1414 00	0 00	0 13		
1428 00	6 12	264 34	1428 00	0 00	0 14		
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1596 00	5 51	262 05	1596 00	0 00	0 16		
1610 00	5 74	263 49	1610 00	0 00	0 12		
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1722 00	5 51	264 61	1722 00	0 00	0 15		
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1750 00	5 68	263 92	1750 00	0 00	0 13		
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1778 00	5 65	264 33	1778 00	0 00	0 12		
1792 00	5 40	262 71	1792 00	0 00	0 11		
1806 00	5 57	261 68	1806 00	0 00	0 11		
1820 00	5 57	264 25	1820 00	0 00	0 13		
1834 00	5 41	267 43	1834 00	0 00	0 16		
1848 00	5 61	264 16	1848 00	0 00	0 17		
1862 00	5 48	263 62	1862 00	0 00	0 17		
1876 00	5 61	263 32	1876 00	0 00	0 15		
1890 00	5 95	267 30	1890 00	0 00	0 16		
1904 00	6 07	263 13	1904 00	0 00	0 17		
1918 00	6 08	265 28	1918 00	0 00	0 15		
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1946 00	4 36	340 78	1946 00	0 00	0 11		

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1974 00	3 28	340 17	1974 00	0 00	0 12
1988 00	3 17	339 90	1988 00	0 00	0 11
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2016 00	2 62	340 08	2016 00	0 00	0 15
2030 00	2 49	342 19	2030 00	0 00	0 12
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2618 00	2 08	361 95	2618 00	0 00	0 21
2632 00	2 01	359 56	2632 00	0 00	0 16

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2702 00	2 10	357 84	2702 00	0 00	0 11	
2716 00	1 88	356 95	2716 00	0 00	0 11	
2730 00	1 98	350 13	2730 00	0 01	0 10	
2744 00	1 92	352 09	2744 00	0 00	0 12	
2758 00	1 95	357 67	2758 00	0 00	0 12	
2772 00	1 97	357 67	2772 00	0 00	0 13	
2786 00	1 98	356 96	2786 00	0 00	0 15	
2800 00	1 90	355 43	2800 00	0 00	0 12	
2814 00	1 83	356 22	2814 00	0 00	0 12	
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2884 00	2 24	357 03	2884 00	0 00	0 15	
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2912 00	2 14	360 06	2912 00	0 00	0 15	
2926 00	2 20	366 54	2926 00	0 00	0 15	
2940 00	2 16	367 27	2940 00	0 00	0 16	
2954 00	2 33	364 94	2954 00	0 00	0 14	
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2982 00	2 22	366 39	2982 00	0 00	0 18	
2996 00	2 07	364 13	2996 00	0 00	0 15	
3010 00	2 10	362 93	3010 00	0 00	0 16	
3024 00	2 08	361 35	3024 00	0 01	0 15	
3038 00	2 28	362 56	3038 00	0 00	0 14	
3052 00	2 22	363 81	3052 00	0 00	0 16	
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3080 00	2 26	362 42	3080 00	0 00	0 15	
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3122 00	2 17	362 52	3122 00	0 00	0 14	
3136 00	2 24	363 03	3136 00	0 00	0 15	
3150 00	2 19	363 88	3150 00	0 00	0 12	
3164 00	2 21	366 38	3164 00	0 00	0 11	
3178 00	2 31	365 41	3178 00	0 00	0 11	
3192 00	2 34	363 63	3192 00	0 00	0 13	
3206 00	2 19	366 97	3206 00	0 01	0 12	
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3234 00	2 15	369 22	3234 00	0 00	0 10	
3248 00	2 16	370 88	3248 00	0 00	0 13	
3262 00	2 20	373 28	3262 00	0 00	0 13	
3276 00	2 19	370 10	3276 00	0 00	0 13	
3290 00	2 22	369 58	3290 00	0 00	0 12	
3304 00	2 27	370 62	3304 00	0 00	0 09	
3318 00	2 33	368 96	3318 00	0 00	0 13	

3332 00	2 42	368 12	3332 00	0 00	0 12		
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3892 00	2 14	374 78	3892 00	0 00	0 09		
3906 00	2 18	370 33	3906 00	0 00	0 11		
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4046 00	3 13	256 93	4046 00	0 00	0 10		
4060 00	3 25	253 83	4060 00	0 01	0 09		
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4130 00	2 90	253 81	4130 00	0 00	0 13		
4144 00	2 88	253 01	4144 00	0 00	0 12		
4158 00	2 87	249 48	4158 00	0 00	0 10		
4172 00	2 98	248 11	4172 00	0 01	0 12		
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4200 00	2 90	245 61	4200 00	0 00	0 13		
4214 00	2 72	245 66	4214 00	0 00	0 10		
4228 00	2 93	241 33	4228 00	0 00	0 15		
4242 00	3 21	240 62	4242 00	0 00	0 12		
4256 00	2 91	242 84	4256 00	0 00	0 11		
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4312 00	2 82	241 32	4312 00	0 00	0 07		
4326 00	2 86	244 43	4326 00	0 00	0 13		
4340 00	2 84	240 91	4340 00	0 00	0 13		
4354 00	3 04	242 44	4354 00	0 00	0 17		
4368 00	3 03	240 38	4368 00	0 00	0 14		
4382 00	3 15	240 18	4382 00	0 00	0 12		
4396 00	2 92	240 74	4396 00	0 00	0 12		
4410 00	3 10	245 39	4410 00	0 00	0 10		
4424 00	3 06	254 81	4424 00	0 00	0 15		
4438 00	2 95	253 60	4438 00	0 00	0 13		
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4494 00	2 84	254 02	4494 00	0 00	0 15		
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4536 00	2 73	240 17	4536 00	0 00	0 12		
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4578 00	2 61	242 88	4578 00	0 00	0 12		
4592 00	2 50	238 59	4592 00	0 00	0 17		
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4634 00	2 63	220 71	4634 00	0 00	0 17		
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4690 00	2 65	206 34	4690 00	0 00	0 22		

4704 00	2 60	200 71	4704 00	0 00	0 19		
4718 00	2 51	205 89	4718 00	0 00	0 27		
4732 00	2 66	216 02	4732 00	0 00	0 13		
4746 00	2 62	216 55	4746 00	0 00	0 13		
4760 00	2 55	212 81	4760 00	0 00	0 18		
4774 00	2 60	209 05	4774 00	0 00	0 14		
4788 00	2 74	206 45	4788 00	0 00	0 14		
4802 00	2 39	207 98	4802 00	0 00	0 10		
4816 00	2 53	214 76	4816 00	0 00	0 12		
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4844 00	2 73	229 46	4844 00	0 00	0 11		
4858 00	2 63	239 56	4858 00	0 00	0 12		
4872 00	2 65	242 03	4872 00	0 00	0 13		
4886 00	2 68	246 68	4886 00	0 00	0 10		
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4942 00	2 76	225 53	4942 00	0 00	0 10		
4956 00	2 47	230 28	4956 00	0 00	0 09		
4970 00	2 77	247 41	4970 00	0 00	0 11		
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5152 00	2 66	221 49	5152 00	0 00	0 16		
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5180 00	2 69	223 44	5180 00	0 00	0 13		
5194 00	2 67	220 85	5194 00	0 00	0 15		
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5264 00	2 75	218 30	5264 00	0 00	0 12		
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5320 00	2 62	216 19	5320 00	0 00	0 11		
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5390 00	2 60	205 77	5390 00	0 00	0 11
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5418 00	2 53	205 90	5418 00	0 00	0 11
5432 00	2 75	204 49	5432 00	0 00	0 10
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5460 00	2 91	204 42	5460 00	0 00	0 10
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5488 00	2 81	207 19	5488 00	0 00	0 13
5502 00	2 68	211 76	5502 00	0 00	0 17
5516 00	2 70	240 18	5516 00	0 00	0 18
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5544 00	2 65	249 03	5544 00	0 00	0 20
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5572 00	2 49	248 58	5572 00	0 00	0 16
5586 00	2 52	257 56	5586 00	0 00	0 13
5600 00	2 54	260 43	5600 00	0 00	0 08
5614 00	2 50	259 99	5614 00	0 00	0 15
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5670 00	2 72	244 77	5670 00	0 00	0 11
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5712 00	2 69	251 57	5712 00	0 00	0 10
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5740 00	2 71	255 25	5740 00	0 00	0 10
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5768 00	2 70	255 75	5768 00	0 00	0 10
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5810 00	2 59	254 27	5810 00	0 00	0 10
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5880 00	2 63	255 83	5880 00	0 00	0 08
5894 00	2 60	257 35	5894 00	0 00	0 08
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5950 00	2 42	247 50	5950 00	0 00	0 09
5964 00	2 43	241 74	5964 00	0 00	0 08
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6006 00	2 93	229 94	6006 00	0 00	0 07
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6076 00	2 59	233 11	6076 00	0 00	0 08		
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6146 00	2 61	226 44	6146 00	0 00	0 06		
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6174 00	2 49	219 03	6174 00	0 00	0 07		
6188 00	2 40	208 90	6188 00	0 00	0 06		
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6216 00	2 75	216 26	6216 00	0 00	0 07		
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6244 00	2 90	253 97	6244 00	0 00	0 09		
6258 00	2 80	248 66	6258 00	0 00	0 10		
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6314 00	2 46	218 19	6314 00	0 00	0 07		
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6356 00	2 25	238 15	6356 00	0 00	0 06		
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6384 00	2 03	232 40	6384 00	0 00	0 07		
6398 00	1 97	230 15	6398 00	0 00	0 07		
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6440 00	2 12	217 54	6440 00	0 00	0 10		
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6468 00	2 15	248 91	6468 00	0 00	0 13		
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6496 00	1 95	254 89	6496 00	0 00	0 12		
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6580 00	2 21	269 50	6580 00	0 00	0 12		
6594 00	1 95	241 24	6594 00	0 00	0 11		
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6762 00	2 02	225 77	6762 00	0 00	0 10		
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6860 00	2 22	276 99	6860 00	0 00	0 10		
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6888 00	2 10	267 50	6888 00	0 00	0 07		
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6944 00	2 05	265 50	6944 00	0 01	0 07		
6958 00	2 23	272 49	6958 00	0 00	0 10		
6972 00	2 10	280 21	6972 00	0 00	0 10		
6986 00	2 04	289 70	6986 00	0 00	0 09		
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7014 00	2 01	308 17	7014 00	0 00	0 10		
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7056 00	1 84	304 57	7056 00	0 00	0 08		
7070 00	1 90	310 23	7070 00	0 00	0 14		
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7112 00	1 91	301 03	7112 00	0 00	0 24		
7126 00	1 69	302 59	7126 00	0 00	0 25		
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7168 00	1 94	283 60	7168 00	0 00	0 25		
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7210 00	1 97	267 98	7210 00	0 00	0 45		
7224 00	2 00	259 38	7224 00	0 00	0 32		
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7280 00	1 98	252 03	7280 00	0 00	0 24		
7294 00	1 89	276 67	7294 00	0 00	0 19		
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7350 00	1 73	235 01	7350 00	0 00	0 13		
7364 00	1 78	228 46	7364 00	0 01	0 25		
7378 00	1 89	230 19	7378 00	0 00	0 25		
7392 00	1 79	218 28	7392 00	0 00	0 14		
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7434 00	1 79	231 43	7434 00	0 00	0 29		

7448 00	1 80	244 64	7448 00	0 00	0 14	
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7476 00	1 90	243 67	7476 00	0 00	0 19	
7490 00	2 00	248 78	7490 00	0 00	0 18	
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7518 00	1 83	241 01	7518 00	0 00	0 22	
7532 00	1 91	241 02	7532 00	0 00	0 31	
7546 00	1 95	244 69	7546 00	0 00	0 25	
7560 00	1 81	246 35	7560 00	0 00	0 34	
7574 00	1 97	245 45	7574 00	0 00	0 22	
7588 00	1 88	240 00	7588 00	0 00	0 17	
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7616 00	1 99	240 75	7616 00	0 00	0 21	
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7644 00	1 84	252 20	7644 00	0 00	0 30	
7658 00	1 85	258 18	7658 00	0 01	0 17	
7672 00	1 72	269 77	7672 00	0 00	0 18	
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7700 00	1 77	252 19	7700 00	0 00	0 21	
7714 00	1 89	245 73	7714 00	0 00	0 17	
7728 00	1 81	242 29	7728 00	0 00	0 24	
7742 00	1 68	241 68	7742 00	0 00	0 21	
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7770 00	1 70	241 85	7770 00	0 00	0 20	
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7812 00	1 85	247 44	7812 00	0 00	0 12	
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7840 00	1 87	252 97	7840 00	0 00	0 12	
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7868 00	1 79	250 50	7868 00	0 00	0 13	
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7924 00	1 77	238 52	7924 00	0 00	0 10	
7938 00	1 87	230 72	7938 00	0 00	0 11	
7952 00	1 70	223 70	7952 00	0 00	0 13	
7966 00	1 96	208 81	7966 00	0 00	0 09	
7980 00	1 72	198 84	7980 00	0 00	0 08	
7994 00	1 64	194 36	7994 00	0 00	0 13	
8008 00	1 77	184 69	8008 00	0 00	0 10	
8022 00	1 60	177 23	8022 00	0 00	0 10	
8036 00	1 74	168 85	8036 00	0 00	0 08	
8050 00	1 75	163 47	8050 00	0 00	0 09	
8064 00	1 84	158 05	8064 00	0 00	0 12	
8078 00	1 76	154 22	8078 00	0 01	0 08	
8092 00	1 87	152 05	8092 00	0 00	0 08	
8106 00	1 69	154 00	8106 00	0 00	0 09	
8120 00	1 64	148 78	8120 00	0 00	0 09	

8134 00	1 68	146 42	8134 00	0 00	0 10		
8148 00	1 55	144 98	8148 00	0 00	0 09		
8162 00	1 62	140 31	8162 00	0 00	0 08		
8176 00	1 66	142 66	8176 00	0 01	0 10		
8190 00	1 72	144 13	8190 00	0 00	0 07		
8204 00	1 74	136 28	8204 00	0 00	0 08		
8218 00	1 85	130 94	8218 00	0 00	0 09		
8232 00	1 76	130 84	8232 00	0 00	0 10		
8246 00	1 65	127 03	8246 00	0 01	0 09		
8260 00	1 77	126 34	8260 00	0 00	0 07		
8274 00	1 70	122 69	8274 00	0 00	0 06		
8288 00	1 62	121 09	8288 00	0 00	0 06		
8302 00	1 69	122 16	8302 00	0 00	0 08		
8316 00	1 82	120 09	8316 00	0 00	0 09		
8330 00	1 76	128 87	8330 00	0 00	0 06		
8344 00	1 75	124 19	8344 00	0 00	0 10		
			8358 00	0 00	0 06		
			8372 00	0 00	0 08		
			8386 00	0 01	0 08		
			8400 00	0 00	0 09		
			8414 00	0 00	0 09		
			8428 00	0 00	0 09		
			8442 00	0 00	0 09		
			8456 00	0 00	0 12		
			8470 00	0 00	0 10		
			8484 00	0 00	0 09		
			8498 00	0 00	0 09		
			8512 00	0 00	0 08		
			8526 00	0 00	0 07		
			8540 00	0 00	0 13		
			8554 00	0 00	0 06		
			8568 00	0 00	0 07		
			8582 00	0 00	0 09		
			8596 00	0 00	0 11		
			8610 00	0 00	0 07		
			8624 00	0 00	0 09		
			8638 00	0 00	0 10		
			8652 00	0 00	0 08		
			8666 00	0 00	0 08		
			8680 00	0 00	0 08		
			8694 00	0 00	0 07		
			8708 00	0 00	0 08		
			8722 00	0 00	0 08		
			8736 00	0 00	0 11		
			8750 00	0 00	0 12		
			8764 00	0 00	0 11		
			8778 00	0 00	0 10		
			8792 00	0 00	0 11		
			8806 00	0 00	0 09		

			8820 00	0 00	0 09		
			8834 00	0 00	0 11		
			8848 00	0 01	0 11		
			8862 00	0 00	0 10		
			8876 00	0 00	0 10		
			8890 00	0 00	0 10		
			8904 00	0 00	0 08		
			8918 00	0 00	0 10		
			8932 00	0 00	0 09		
			8946 00	0 00	0 10		
			8960 00	0 00	0 07		
			8974 00	0 00	0 08		
			8988 00	0 01	0 10		
			9002 00	0 00	0 08		
			9016 00	0 00	0 10		
			9030 00	0 00	0 11		
			9044 00	0 00	0 16		
			9058 00	0 00	0 17		
			9072 00	0 00	0 21		
			9086 00	0 00	0 18		
			9100 00	0 00	0 25		
			9114 00	0 00	0 24		
			9128 00	0 00	0 26		
			9142 00	0 00	0 25		
			9156 00	0 00	0 26		
			9170 00	0 00	0 27		
			9184 00	0 00	0 23		
			9198 00	0 00	0 27		
			9212 00	0 00	0 23		
			9226 00	0 00	0 27		
			9240 00	0 00	0 23		
			9254 00	0 01	0 20		
			9268 00	0 00	0 25		
			9282 00	0 00	0 30		
			9296 00	0 00	0 32		
			9310 00	0 00	0 33		
			9324 00	0 00	0 30		
			9338 00	0 00	0 25		
			9352 00	0 00	0 28		
			9366 00	0 00	0 31		
			9380 00	0 00	0 28		
			9394 00	0 00	0 22		
			9408 00	0 00	0 24		

APPENDIX B

PDM LABORATORY RESULTS							
INSIDE AVERAGE PARTICLE COUNTS BETWEEN RANGES							
Particle range	(0.7 to 1)	(1 to 2)	(2 to 3.5)	(3.5 to 5)	(5 to 7.5)	(7.5 to 10)	(10 to 15)
	3.561243	1.021328	0.157221	0.035344	0.01036	0.002438	0.002438
OUTSIDE AVERAGE PARTICLE COUNTS BETWEEN RANGES							
Particle range	(0.7 to 1)	(1 to 2)	(2 to 3.5)	(3.5 to 5)	(5 to 7.5)	(7.5 to 10)	(10 to 15)
	711.1773	202.063	17.58135	5.208581	2.223644	0.670323	0.298598
PENETRATION (INSIDE/OUTSIDE)							
Particle range	(0.7 to 1)	(1 to 2)	(2 to 3.5)	(3.5 to 5)	(5 to 7.5)	(7.5 to 10)	(10 to 15)
	0.005008	0.005055	0.008942	0.006788	0.004659	0.003636	0.008163
EFFICIENCIES AT EACH PARTICLE RANGE (1-Penetration)							
Particle range	(0.7 to 1)	(1 to 2)	(2 to 3.5)	(3.5 to 5)	(5 to 7.5)	(7.5 to 10)	(10 to 15)
	0.994992	0.994945	0.991058	0.993212	0.995341	0.996364	0.991837
PROTECTION FACTORS (Outside/Inside)							
Particle range	(0.7 to 1)	(1 to 2)	(2 to 3.5)	(3.5 to 5)	(5 to 7.5)	(7.5 to 10)	(10 to 15)
	199.6992	197.8335	111.8256	147.3103	214.6471	275	122.5

APPENDIX C

FEILD EVALUATION						
Particle Concentrations Inside			Particle Concnetrations Outside			
TIME	>3 0	0 3-3 0	TIME	>3 0	0 3-3 0	
SEC	PAR/CC	PAR/CC	SEC	PAR/CC	PAR/CC	
0	0 022959	2 331122	0	0 188265	38 79949	
14	0 015306	2 219388	14	0 179082	38 05102	
28	0 006122	2 511735	28	0 254082	61 30102	
42	0 053571	2 413776	42	0 156122	36 22653	
56	0 042857	2 504082	56	0 218878	35 39235	
70	0 145408	3 319898	70	0 169898	35 57143	
84	0 122449	3 081122	84	0 195918	35 05867	
98	0 09949	2 658673	98	0 183673	36 27092	
112	0 194388	4 181633	112	0 189796	35 16276	
126	0 091837	3 316837	126	0 192857	35 12143	
140	0 05051	2 802041	140	0 157653	36 47908	
154	0 047449	2 643367	154	0 159184	40 19694	
168	0 068878	2 680102	168	0 234184	34 55663	
182	0 045918	2 686224	182	0 191327	43 60867	
196	0 035204	2 42602	196	0 367347	136 9622	
210	0 035204	2 804082	210	0 543367	150 375	
224	0 032143	2 419898	224	0 404082	123 0444	
238	0 032143	2 678571	238	0 361224	142 1617	
252	0 041327	2 418367	252	0 345918	143 5776	
266	0 021429	2 44898	266	0 296939	121 774	
280	0 029082	2 459694	280	0 261735	99 98112	
294	0 035204	2 698469	294	0 237245	85 14337	
308	0 02602	2 363265	308	0 194388	73 21684	
322	0 021429	2 585204	322	0 309184	138 1372	
336	0 016837	2 611224	336	0 292347	124 5367	
350	0 021429	2 422959	350	0 264796	116 4566	
364	0 018367	2 288265	364	0 188265	70 21837	
378	0 042857	2 55	378	0 20051	76 05153	
392	0 071939	2 781122	392	0 341327	140 3204	
406	0 070408	2 566837	406	0 381122	144 5571	
420	0 079592	2 768878	420	0 24949	127 7923	
434	0 084184	2 719898	434	2 364796	73 55357	
448	0 079592	2 912755	448	1 414286	38 32806	
462	0 110204	3 078061	462	0 886224	33 06429	
476	0 087245	2 932653	476	1 561224	34 54592	
490	0 062755	2 703061	490	0 809694	33 71786	
504	0 082653	2 782653	504	4 769388	38 6801	
518	0 067347	2 712245	518	0 463776	33 31071	
532	0 052041	2 583673	532	1 533673	34 67143	
546	0 045918	2 531633	546	15 04133	61 67908	
560	0 042857	2 205612	560	25 57041	73 18469	
574	0 045918	2 340306	574	31 4648	68 32806	
588	0 044388	2 637245	588	59 25818	69 4852	

602	0 027551	2 553061		602	40 07296	74 94031
616	0 047449	2 464286		616	16 87194	49 56582
630	0 058163	2 193367		630	6 494388	48 28469
644	0 039796	2 297449		644	1 832143	33 28929
658	0 058163	2 171939		658	6 087245	46 07296
672	0 033673	2 031122		672	1 945408	39 28316
686	0 044388	2 207143		686	0 214286	32 33112
700	0 045918	2 289796		700	0 79898	32 43827
714	0 044388	2 227041		714	2 554592	33 29847
728	0 030612	2 170408		728	0 788265	32 00969
742	0 041327	2 520918		742	0 338265	32 18112
756	0 039796	2 231633		756	7 161735	47 11684
770	0 02602	2 432143		770	37 18929	72 14082
784	0 053571	2 202551		784	37 43571	62 60204
798	0 05051	2 462755		798	52 16327	61 98061
812	0 070408	2 872959		812	36 09949	61 17092
826	0 061224	2 687755		826	2 455102	39 36122
840	0 045918	2 407653		840	11 69082	54 37041
854	0 041327	2 311224		854	9 189796	50 86531
868	0 041327	2 378571		868	11 39541	43 61939
882	0 039796	2 295918		882	4 07602	36 92296
896	0 030612	2 364796		896	0 414796	31 36837
910	0 029082	2 05102		910	0 394898	31 89184
924	0 016837	2 003571		924	5 315816	37 6699
938	0 02602	1 960714		938	1 333163	33 94898
952	0 041327	1 980612		952	18 22959	49 33316
966	0 09949	2 346429		966	31 04082	56 5301
980	0 058163	2 159694		980	85 23061	60 08571
994	0 035204	2 214796		994	5 364796	38 46122
1008	0 04898	2 243878		1008	57 29082	57 38571
1022	0 058163	2 306633		1022	67 54592	60 82194
1036	0 030612	2 144388		1036	49 27806	63 67959
1050	0 04898	2 248469		1050	56 42143	63 18827
1064	0 047449	2 083163		1064	20 6051	54 96122
1078	0 041327	2 295918		1078	46 66837	66 4898
1092	0 030612	2 081633		1092	21 42551	52 55051
1106	0 042857	2 228571		1106	1 114286	33 59694
1120	0 04898	2 191837		1120	1 189286	32 89286
1134	0 045918	2 364796		1134	9 17602	38 76429
1148	0 068878	2 464286		1148	19 72959	54 72398
1162	0 045918	2 421429		1162	10 49847	46 81071
1176	0 05051	2 644898		1176	2 012755	33 68724
1190	0 041327	2 530102		1190	7 327041	39 77449
1204	0 029082	2 514796		1204	9 717857	48 67959
1218	0 035204	2 478061		1218	22 57653	66 29388
1232	0 045918	2 398469		1232	40 45408	68 01122
1246	0 030612	2 248469		1246	70 4801	58 66531
1260	0 042857	2 272959		1260	67 07755	57 72704
1274	0 052041	2 259184		1274	38 34796	56 13367

1288	0 038265	1 99898		1288	25 42806	47 66786
1302	0 035204	2 028061		1302	3 088776	35 74745
1316	0 052041	2 095408		1316	4 458673	34 77551
1330	0 035204	2 103061		1330	12 34286	41 10918
1344	0 036735	1 82602		1344	0 593878	30 91684
1358	0 052041	1 985204		1358	9 330612	31 90867
1372	0 082653	2 089286		1372	50 25918	52 29949
1386	0 110204	2 130612		1386	34 93316	56 03571
1400	0 070408	2 037245		1400	2 703061	59 66786
1414	0 036735	2 021939		1414	0 375	40 22449
1428	0 022959	1 842857		1428	0 312245	46 97296
1442	0 021429	1 65		1442	0 241837	58 20612
1456	0 015306	1 807653		1456	0 226531	54 3398
1470	0 02449	1 875		1470	0 257143	61 47398
1484	0 036735	1 758673		1484	0 333673	120 7423
1498	0 067347	1 591837		1498	0 341327	129 626
1512	0 030612	1 429592		1512	0 25102	69 05051
1526	0 045918	1 483163		1526	0 240306	44 65714
1540	0 041327	1 365306		1540	0 240306	47 00204
1554	0 047449	1 285714		1554	1 836735	57 04439
1568	0 012245	1 219898		1568	0 420918	101 0051
1582	0 021429	1 423469		1582	1 053061	63 2801
1596	0 019898	1 181633		1596	0 189796	58 16633
1610	0 035204	1 258163		1610	0 20051	55 90102
1624	0 053571	1 45102		1624	0 234184	44 5102
1638	0 041327	1 353061		1638	0 192857	56 58673
1652	0 027551	1 503061		1652	0 15	47 08776
1666	0 019898	1 581122		1666	0 179082	44 55612
1680	0 016837	1 648469		1680	0 142347	35 32959
1694	0 007653	1 542857		1694	0 195918	49 22449
1708	0 033673	1 588776		1708	0 159184	52 125
1722	0 035204	1 706633		1722	0 166837	46 37602
1736	0 036735	1 464796		1736	0 153061	35 06786
1750	0 038265	1 764796		1750	0 162245	33 77908
1764	0 029082	1 608673		1764	0 179082	36 59541
1778	0 042857	1 683673		1778	0 214286	34 13571
1792	0 02602	1 54898		1792	0 20051	54 94133
1806	0 02449	1 418878		1806	17 47041	82 8398
1820	0 030612	1 369898		1820	27 88622	75 8602
1834	0 032143	1 62551		1834	1 541327	183 8464
1848	0 032143	1 530612		1848	0 717857	160 0546
1862	0 032143	1 547449		1862	0 373469	89 91888
1876	0 027551	1 518367		1876	19 96071	76 14337
1890	0 035204	1 553571		1890	72 36735	64 00408
1904	0 036735	1 406633		1904	60 66122	60 93673
1918	0 045918	1 484694		1918	87 47296	51 97347
1932	0 030612	1 467857		1932	10 8398	46 12959
1946	0 029082	1 604082		1946	0 769898	32 7
1960	0 045918	1 397449		1960	0 569388	32 03571

1974	0 029082	1 515306		1974	0 269388	31 3699
1988	0 052041	1 596429		1988	0 433163	31 21378
2002	0 035204	1 581122		2002	0 762245	31 74643
2016	0 029082	1 535204		2016	16 34082	46 55357
2030	0 019898	1 490816		2030	24 07194	64 59184
2044	0 022959	1 642347		2044	25 41735	62 0648
2058	0 019898	1 593367		2058	64 46786	69 12704
2072	0 027551	1 565816		2072	96 20816	63 33673
2086	0 030612	1 542857		2086	71 04337	65 13061
2100	0 027551	1 69898		2100	96 44694	64 40357
2114	0 010714	1 490816		2114	40 65153	73 14949
2128	0 015306	1 198469		2128	88 03469	67 4801
2142	0 009184	1 411224		2142	10 0898	41 90969
2156	0 016837	1 247449		2156	3 440816	34 54439
2170	0 047449	1 536735		2170	1 284184	32 19643
2184	0 059694	1 434184		2184	6 439286	37 18622
2198	0 055102	1 457143		2198	38 27755	54 76837
2212	0 094898	1 596429		2212	50 34184	71 11531
2226	0 052041	1 963776		2226	9 373469	40 11888
2240	0 019898	1 783163		2240	1 714286	33 7102
2254	0 045918	1 718878		2254	5 618878	36 82653
2268	0 053571	1 838265		2268	0 34898	31 73418
2282	0 065816	1 741837		2282	4 477041	36 28163
2296	0 047449	1 611735		2296	1 910204	38 14898
2310	0 036735	1 746429		2310	0 451531	58 57653
2324	0 055102	1 630102		2324	1 388265	68 55153
2338	0 038265	1 682143		2338	55 32551	65 68776
2352	0 02602	1 501531		2352	24 93827	49 77398
2366	0 030612	1 614796		2366	7 180102	41 95102
2380	0 02449	1 581122		2380	20 89745	52 25357
2394	0 018367	1 372959		2394	8 005102	42 25714
2408	0 02602	1 447959		2408	1 646939	33 63061
2422	0 042857	1 483163		2422	10 67755	40 32245
2436	0 045918	1 516837		2436	20 0801	63 43929
2450	0 030612	1 481633		2450	13 19388	57 56786
2464	0 027551	1 418878		2464	15 54643	56 91582
2478	0 042857	1 421939		2478	30 0551	66 3398
2492	0 05051	1 429592		2492	88 29184	70 97755
2506	0 02449	1 446429		2506	27 06122	61 98061
2520	0 036735	1 40051		2520	49 23061	67 6852
2534	0 02602	1 391327		2534	53 18418	60 59082
2548	0 015306	1 39898		2548	55 40051	64 82143
2562	0 019898	1 527551		2562	70 83367	70 58724
2576	0 021429	1 412755		2576	96 64898	66 16378
2590	0 022959	1 435714		2590	62 32194	66 02143
2604	0 015306	1 395918		2604	64 8199	61 94082
2618	0 019898	1 421939		2618	6 846429	38 31888
2632	0 016837	1 379082		2632	0 890816	34 1449
2646	0 016837	1 571939		2646	1 421939	32 38316

2660	0 02449	1 564286		2660	0 538776	32 19031
2674	0 02449	1 440306		2674	14 42143	43 19694
2688	0 033673	1 428061		2688	4 604082	35 47194
2702	0 02449	1 338224		2702	1 028571	31 82296
2716	0 02602	1 522959		2716	9 061224	37 74337
2730	0 02449	1 294898		2730	44 62806	64 07296
2744	0 032143	1 414286		2744	21 48214	54 89082
2758	0 013776	1 379082		2758	52 88112	73 19082
2772	0 013776	1 408163		2772	53 36173	66 9
2786	0 022959	1 594898		2786	99 94745	63 42398
2800	0 021429	1 576531		2800	16 46327	51 96429
2814	0 02449	1 484694		2814	16 11735	53 43673
2828	0 012245	1 45102		2828	27 74847	67 2551
2842	0 027551	1 432653		2842	62 7949	72 22041
2856	0 021429	1 35		2856	90 15918	65 20714
2870	0 016837	1 425		2870	42 65663	54 47755
2884	0 010714	1 405102		2884	5 152041	35 2148
2898	0 02602	1 417347		2898	1 52449	30 44541
2912	0 027551	1 498469		2912	1 336224	29 64337
2926	0 022959	1 331633		2926	2 987755	33 11786
2940	0 019898	1 40051		2940	0 880102	30 0352
2954	0 030612	1 382143		2954	16 17551	42 47602
2968	0 036735	1 322449		2968	16 95459	57 49133
2982	0 027551	1 579592		2982	51 22194	63 04898
2996	0 009184	1 440306		2996	26 55459	48 58929
3010	0 012245	1 29949		3010	2 981633	34 45255
3024	0 027551	1 389796		3024	34 87194	46 13724
3038	0 021429	1 32398		3038	101 8821	69 34439
3052	0 009184	1 579592		3052	54 27245	62 10306
3066	0 019898	1 412755		3066	9 085714	39 48061
3080	0 019898	1 235204		3080	0 64898	32 30357
3094	0 016837	1 282653		3094	0 488265	31 64847
3108	0 030612	1 423469		3108	4 166327	34 66224
3122	0 02602	1 578061		3122	1 314796	31 42194
3136	0 041327	1 481633		3136	1 628571	30 90306
3150	0 044388	1 584184		3150	8 797959	39 00765
3164	0 030612	1 359184		3164	5 187245	35 61735
3178	0 064286	2 256122		3178	16 87347	50 53163
3192	0 062755	2 311224		3192	8 265306	39 43929
3206	0 062755	2 098469		3206	22 92398	49 57653
3220	0 055102	2 367857		3220	24 38571	59 15653
3234	0 082653	2 22398		3234	8 482653	42 24949
3248	0 056633	2 357143		3248	45 825	70 54439
3262	0 065816	2 288265		3262	12 9551	45 34133
3276	0 065816	2 444388		3276	1 686735	32 55153
3290	0 094898	2 90051		3290	0 601531	31 04541
3304	0 039796	2 393878		3304	28 78622	55 0852
3318	0 064286	2 155102		3318	4 865816	36 75612
3332	0 047449	2 288265		3332	1 383673	33 15918

3346	0 053571	2 380102		3346	0 909184	33 21735
3360	0 033673	2 253061		3360	0 512755	32 48878
3374	0 027551	2 257653		3374	0 655102	32 51327
3388	0 059694	2 519388		3388	0 918367	32 39694
3402	0 038265	2 715306		3402	0 252551	94 14796
3416	0 032143	2 589796		3416	0 192857	69 45306
3430	0 039796	2 563776		3430	0 179082	52 64082
3444	0 039796	2 216327		3444	0 17602	35 29592
3458	0 035204	2 320408		3458	0 163776	36 32908
3472	0 071939	2 309694		3472	0 194388	71 14286
3486	0 042857	2 340306		3486	0 264796	77 79796
3500	0 039796	2 170408		3500	0 254082	63 2602
3514	0 02602	2 219388		3514	0 355102	110 0526
3528	0 047449	2 064796		3528	0 205102	44 1949
3542	0 036735	2 155102		3542	15 17143	58 34082
3556	0 032143	2 20102		3556	53 49796	68 83469
3570	0 032143	2 292857		3570	34 63163	60 00306
3584	0 047449	2 271429		3584	47 23469	59 34031
3598	0 033673	2 416837		3598	35 77347	51 8648
3612	0 035204	2 412245		3612	1 744898	35 82551
3626	0 039796	2 418367		3626	0 477551	33 21276
3640	0 038265	2 208673		3640	0 231122	32 79949
3654	0 02602	2 265306		3654	0 70102	32 65255
3668	0 035204	2 497959		3668	0 606122	31 89949
3682	0 038265	2 283673		3682	0 188265	32 14439
3696	0 039796	2 422959		3696	49 03776	54 27092
3710	0 036735	2 006633		3710	3 269388	35 60357
3724	0 05051	2 187245		3724	18 27092	48 12398
3738	0 027551	2 110714		3738	14 38469	50 17959
3752	0 039796	2 222449		3752	16 87653	57 77908
3766	0 041327	2 280612		3766	18 85408	70 41735
3780	0 047449	2 136735		3780	31 78622	65 18112
3794	0 030612	2 178061		3794	75 95357	64 0148
3808	0 047449	2 263776		3808	50 87602	59 84082
3822	0 02449	2 228571		3822	50 92347	58 37143
3836	0 02449	1 801531		3836	37 86122	51 28929
3850	0 02449	2 185714		3850	5 833163	35 75357
3864	0 044388	1 821429		3864	7 314796	37 125
3878	0 038265	2 081633		3878	14 90969	37 92551
3892	0 019898	1 680612		3892	31 11429	57 10561
3906	0 019898	1 957653		3906	14 99541	66 02755
3920	0 038265	1 939286		3920	24 42704	57 83571
3934	0 04898	1 888776		3934	24 49745	63 14847
3948	0 027551	2 015816		3948	56 13061	64 17551
3962	0 019898	1 893367		3962	15 30153	51 39949
3976	0 021429	1 864286		3976	12 55102	48 52041
3990	0 032143	1 913265		3990	7 538265	40 575
4004	0 016837	1 677551		4004	17 5148	44 50408
4018	0 021429	1 928571		4018	59 13214	63 21735

4032	0 022959	1 666837		4032	47 69082	61 32704
4046	0 038265	2 077041		4046	73 3898	69 49286
4060	0 021429	1 717347		4060	79 29031	62 77194
4074	0 022959	1 959184		4074	34 78929	57 03367
4088	0 027551	1 792347		4088	14 20867	42 13469
4102	0 02602	1 786224		4102	2 175	33 88622
4116	0 018367	1 910204		4116	2 156633	31 9301
4130	0 021429	1 789286		4130	0 587755	30 96122
4144	0 021429	1 798469		4144	0 298469	31 70663
4158	0 039796	2 110714		4158	0 69949	31 25663
4172	0 027551	1 954592		4172	0 87551	31 55816
4186	0 030612	2 101531		4186	13 33622	42 34592
4200	0 019898	1 945408		4200	21 49592	47 76735
4214	0 021429	2 081633		4214	15 56633	44 48265
4228	0 02449	2 109184		4228	68 09388	65 73367
				4242	60 00612	63 4898
				4256	56 78112	59 96714
				4270	52 56122	62 0602
				4284	60 75306	63 3551
				4298	52 06531	62 02041
				4312	2 129082	33 525
				4326	0 831122	31 19388
				4340	0 431633	30 64286
				4354	0 188265	29 82092
				4368	0 577041	30 10714
				4382	0 987245	31 00408
				4396	30 45765	56 55459
				4410	21 56633	61 80459
				4424	51 71786	64 85051
				4438	64 79082	67 15408
				4452	31 76327	67 88265
				4466	25 8949	60 34745
				4480	1 380612	32 25918
				4494	2 543878	32 24235
				4508	5 026531	36 09949
				4522	2 222449	32 2898
				4536	20 78112	47 35408
				4550	47 10459	63 70561
				4564	23 65561	61 20765
				4578	2 609694	58 68367
				4592	1 126531	58 99898
				4606	1 982143	42 16531
				4620	2 005102	52 62551

APPENDIX D

PDM RESULTS DURING FIELD EVALUATION

OUTSIDE AVERAGES IN EACH PARTICLE RANGE FOR EACH SEPERATE RUN

Particle Size Range	(0 35-0 5)	(0 5-0 75)	(0 75-1)	(1-2)	(2-3 5)	(3 5-5)	(5-6 5)	(>6 5)
RUN 1	65192	14061 08	4088 077	9297 923	5970 615	10012 31	5769 615	10431 92
RUN 2	66758 8	11620 2	3686 133	8279 733	6431 133	10146 47	5778 8	11100 27
RUN 3	79760 75	13047 69	3808 313	9765 938	6733 25	11699 94	6718 813	11758 31
RUN 4	63201 14	11598 07	3842 357	6964 571	5303	7800 429	4325 5	8332 5

INSIDE AVERAGES IN EACH PARTICLE RANGE FOR EACH SEPERATE RUN

Particle Size Range	(0 35-0 5)	(0 5-0 75)	(0 75-1)	(1-2)	(2-3 5)	(3 5-5)	(5-6 5)	(>6 5)
RUN 1	1068 615	405 6923	151 4615	74 38462	28	10 89231	2 692308	3
RUN 2	620 1	253 4333	101 1667	54 9	20 2	6 466667	2 6	2 8
RUN 3	806 875	345 25	139 6875	71 8125	26 5625	11 125	2 1875	2 25
RUN 4	735 8929	245 5	97	54 39286	19 25	6 5	2 607143	2 142857

PENETRATION (INSIDE/OUTSIDE) SUMMARY

Particle Size Range	(0 35-0 5)	(0 5-0 75)	(0 75-1)	(1-2)	(2-3 5)	(3 5-5)	(5-6 5)	(>6 5)
RUN 1	0 016392	0 028852	0 03705	0 008	0 00469	0 001068	0 000467	0 000288
RUN 2	0 009289	0 02181	0 027445	0 006631	0 003141	0 000637	0 00045	0 000252
RUN 3	0 010116	0 026461	0 036709	0 007353	0 003945	0 000951	0 000326	0 000191
RUN 4	0 011644	0 021167	0 025245	0 00781	0 00363	0 000833	0 000603	0 000257
avg penetration	0 01186	0 024572	0 031612	0 007449	0 003851	0 000872	0 000461	0 000247
Grimm mean diameter	0 41833	0 612372	0 866025	1 414214	2 645751	4 1833	5 700877	gt 6 5
Protection factor	84 31844	40 69598	31 63349	134 2549	259 6458	1146 33	2168 172	4047 159
(outside/inside)								
efficiencies	0 98814	0 975428	0 968388	0 992551	0 996149	0 999128	0 999539	0 999753
(1 - penetration)								