12-1996

Liquid Agglomeration of Ink Particles in Deinking

Timothy J. Bowen
Western Michigan University

Liquid Agglomeration of Ink Particles in Deinking

By

Timothy J. Boven

This thesis is submitted

in partial fulfillment of

the course requirements for a

Bachelor of Science Degree

Western Michigan University

Kalamazoo, Michigan

December 3, 1996

Abstract

Liquid agglomeration is defined by references as a separation process (3). For the purpose of this thesis project, it is the process of using a hydrocarbon oil, dispersed in water, to a pulp slurry, to agglomerate the ink particles and then float them to the top. The idea behind this research is that the sludge produced will have a higher BTU value due to the hydrocarbon oil, which will make incineration a more feasible means of disposal. The preliminary work consisted of determining whether or not the ink particles would agglomerate with hexadecane. It was found that the ink particles did in fact agglomerate and hexadecane was an efficient agglomerating oil. Previous work had found that internal starch and internal size inhibited agglomeration, however, it is believed that if the right surface chemistry could be induced onto the fiber, the agglomeration process would be promoted (3). This was attempted by evaluating four different surfactants to determine if any of them could promote agglomeration. BRD2340, BRD2342, Busperse 47, and Busperse 59 were the surfactants chosen for evaluation. It was found that BRD2342 and BRD2340 were incapable of promoting agglomeration. However, Busperse 47 and Busperse 59 did promote agglomeration, with Busperse 59 visually performing the best. After the pulp had been run through the agglomeration cells, it was evaluated for pulp cleanliness. This was done by making brightness pads and running the pads through the Spec*Scan 2000 to determine dirt counts. It was found that the agglomeration cells could not perform as efficiently as an air flotation cell. However, it was observed that the liquid agglomeration process did increase the ink particles size. It is hypothesized that this may prove favorable in an air flotation cell. It can be concluded that the liquid agglomeration process needs additional research.

Table of Contents

Introduction

The recycling of paper is becoming more and more prevalent. On February 13, 1990, the U.S. paper industry announced a national goal of 40% paper recovery for recycling by 1995 (1). The rate of recycling can only be expected to increase in the future, especially with the increase in public concern for the environment and new government legislation. With an increase in recycling, there is also an increase in the amount of sludge produced. Currently, landfills are the number one means of disposal. However, with landfill space decreasing, landfill disposal cost increasing, and the increase in government legislation, a new means of disposal needs to be found (1). Incineration is a possibility, however it has its drawbacks due to the high water content and low BTU value of sludge (1). For this reason, it is not widely used.

Currently, forth flotation is main process for removing ink particles. In 1992, it was reported worldwide that there were approximately 450 deinking systems either operating or under construction, with approximately 80% of these installations utilizing a flotation deinking module (1). Flotation is a effective means of removing thermoplastic inks, such as the ones in many laser printers and photocopy machines. The flotation process can be divided into three major stages. They are as follows: collision of the particles with the air bubbles, attachment of the particles to the air bubbles, and removal of the air bubble-particle from the pulp. (1) In flotation, the ink particles attach to the air bubbles because they are hydrophobic, while the fibers do not, because they are hydrophilic (2). The ink particles then float to the top forming a foam which can be skimmed off. This froth forms a great deal of sludge which is mostly landfilled.

An alternative to flotation is a process commonly referred to by references as liquid agglomeration. References define the liquid agglomeration process as a separation technique (3). Liquid agglomeration, for this project, is the process of adding a hydrocarbon oil dispersed in water to a pulp slurry for the purpose of agglomerating ink particles and floating them to the top of the slurry for removal. The process operates by the same means as does air flotation, with respect to the oil agglomeration taking advantage of the difference in toner and fiber wettability. Like flotation, the oil droplets attach to the toner particles because they are hydrophobic and not to the fibers because they are hydrophilic. The oil/toner droplets then collide with other oil/toner droplets forming 1mm to 1cm spheres of ink and oil which float to the top. (3). The oil acts as binder for the ink particles. From there, the oil/ink mixture can be separated by gravity settling or centrifugal cleaners (3). Hydrocarbons, such as gasoline, benzene, and hexadecane, are nonpolar and therefore are incapable of forming hydrogen bonds with water. For this reason, these hydrocarbon oils will not disperse in water. Due to the hydrocarbon oil's hydrophobic characteristic, it will have a natural affinity to other hydrophobic particles, such as thermoplastic inks. Therefore, it is believed that the liquid agglomeration process can be made technically feasible. The oil/ink mixture should theoretically have a higher BTU value than conventional sludge produced in a air flotation cell. This sludge byproduct then can be potentially burned in a furnace to recover its high BTU value. This would reduce the outgoing sludge currently going to landfills. However, it is not the goal of this thesis to determine the BTU value of the sludge produced. The goal of this thesis is to determine whether or not liquid agglomeration can

be made a viable process. Increasing the BTU value of the sludge is only one of reason for the research.

Background Discussion

After doing an extensive literature search, only one article was found that was directly related to this project. It was written by professor John Berg and a graduate student by the name of Bret Snyder from the University of Washington (3). In their experiment, they dispersed Apple Laser Writer toner particles in a bucket of water. They then added a hydrocarbon oil (hexadecane) dispersed in water into the bucket. The mixture was agitated to see if an agglomeration of oil droplets and the toner particles would occur. It was observed that the hexadecane did indeed agglomerate the ink particles. Berg and Synder then found that the amount of hexadecane added to the bucket affected the type of agglomerates formed (3). At first, with low oil dosages, the oil agglomerates were small. As more hexadecane was added, spherical shaped balls started to form. They eventually reached the capillary state, where the amount of oil was equal to that which exactly filled the pore volume between the toner particles (3). As they continued to add more oil, a liquid-liquid transfer took place, in which the toner particles became dispersed in the oil phase. This resulted in a reduction of strength in the agglomerates, in which the agglomerates become soft and spongy. Therefore, they concluded the ideal amount of hexadecane to be added, is that which is equal to the pore volume between the toner particles. This amount came out to approximately 20 #/ton (3).

They then repulped standard copy paper, dispersed it in a bucket, added the toner particles, and then added the dispersed oil. This time however, agglomeration did not occur. After that, they performed the same experiment with filter paper, which contains no additives or fillers, in which agglomeration was observed to occur (3). This posed the question, "What in the standard copy paper was inhibiting agglomeration of the ink

particles?". Berg and Snyder then continued to isolate all of the components of the copy paper. It was found that the internal starch and internal sizing agents of the paper blocked the agglomeration process. It was hypothesized that the starch adsorbed at the oil-water interfaces, stabilizing the oil droplet against attaching to the toner particles (3). It was also hypothesized that the internal sizing agent (AKA in this case) formed hydrophobic patches on the outside walls of the fiber (3). The oil droplets then had a higher affinity to these spots, in which they attached. Thus, it was concluded that internal starch and internal size offsets the effects of hexadecane in agglomeration of ink particles (3). They observed in the agglomeration cell that the oil droplets flocculated with the fibers, supporting this idea. It is believed that if the right surface chemistry is induced on the fiber, that agglomeration can be promoted. (3)

This process is causing great interest in the separating of coal from ash. Coal particles are hydrophobic, like that of ink particles. The ash is hydrophilic, like that of the pulp. The coal particles can then be easily separated through the liquid agglomeration process (3). Just as flotation was adopted to deinking from the mineral processing field, liquid agglomeration may be adopted as well.

The objective of this research is to see if the correct surface chemistry can be induced on to the fibers to promote agglomeration. Based on Berg and Synder's findings, four different surfactants are going to be evaluated to see if they can offset the effects of internal size and internal starch to promote agglomeration. It is not the goal of this project to evaluate economical feasibility or BTU value of the sludge produced. The process has to prove to be technically feasible before the economics can be determined.

Experimental Design

This thesis project is going to be carried out in three distinct parts. Each portion will be discussed separately. All of the raw data collected from the experimental design can be found in the results section of this report. The calculations used to determine pulping conditions, agglomeration conditions, and flotation conditions can be found in Appendix I. The printouts produced by the Spec*Scan 2000, used to determine dirt counts, can be found in Appendix II.

Part I

Part I of this experiment was designed to determine whether or not the toner particles would agglomerate with a hydrocarbon oil. Hexadecane was used as the agglomerating oil because it is nonvolatile (boiling point 287°C), relatively nontoxic, forms a high interfacial tension with water (50 mNm^{-1}) (4) , and represents a typical fuel oil or diesel fuel, which would be a cheap source of an agglomerating oil (3). Toner particles from a Cannon NP2000 photocopy machine were used to represent thermoplastic inks due to ease of accessibility.

Hexadecane was homogenized in water at 1% using a standard drink mixer. After the oil was dispersed in water, the toner particles were added and allowed to mix using a magnetic stirrer. The magnetic stirrer was then slowed down to allow the agglomeration process to occur and allow the oil/toner particles to rise to the top. Observations were then recorded.

Part II

After the completion of Part I of the experimental design, it was concluded that the ink particles did in fact agglomerate with hexadecane. Based on this data, it was time to

proceed with part II of the experimental design. After researching past work, part II was designed to alter the surface chemistry on the fiber to enhance agglomeration (3). This portion of the experimental design was based on the work done at the University of Washington (3). It differed from their work by a surfactant to the agglomeration cell to determine if it would offset the effects of internal starch and internal size, which Berg and Synder found to inhibit the agglomeration process (3). Four different surfactants were analyzed. The surfactants used in this project were BRD2342, BRD2340, Busperse 47, and Busperse 59, all of which were donated by Buckman Laboratories. Hexadecane was once again used as the agglomerating oil.

Repulping standard office paper with a standard print was the first thing done. The print was the same on both sides and can be found in Appendix III (only one sided is printed in Appendix III). The paper was repulped at 1.2% consistency in a British Disintegrator for five minutes using deionized water. It was decided to repulp the paper for five minutes because anything less would cause for inefficient pulping, thus leaving large pieces of paper in the slurry. It took a total of ten two liter batches to acquire enough pulp for all of the different agglomeration runs. This amounted for a total of 250 grams of oven dried fiber.

Upon repulping of the fiber, all of the batches were mixed together in a five gallon bucket. This was to ensure uniform ink distribution throughout the slurry. At this point, a 700 ml pulp sample was obtained. This sample was placed in a two liter beaker and allowed to stir for 30 minutes at 40 rpm in the six jar stirrer. After stirring, visual observations were made and a photograph were taken for further comparison. Two brightness pads were made, weighing approximately 4 grams. The pads were then pressed

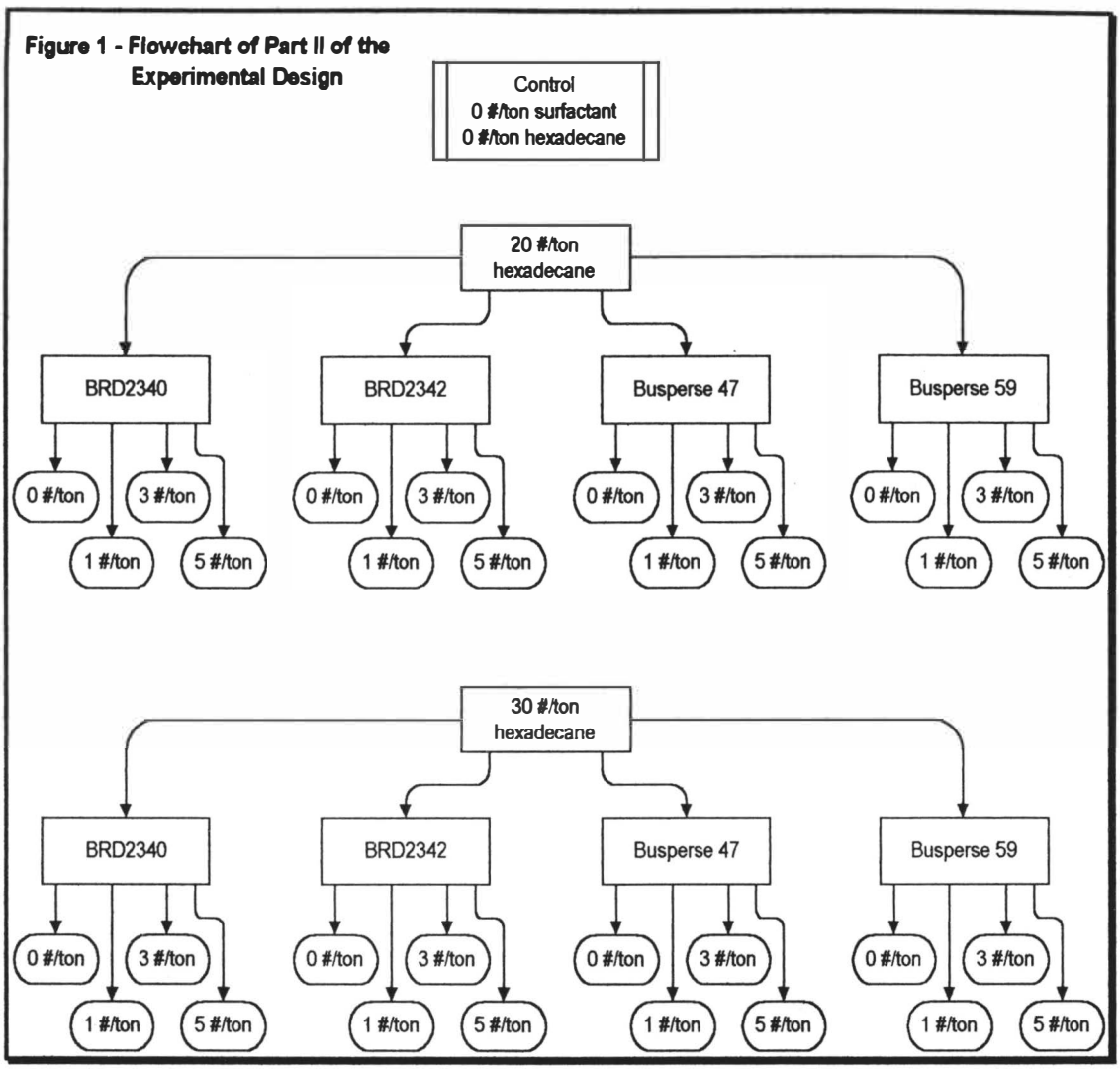
in the British handsheet maker press for 20 minutes at 50 psig. The reason the pads were pressed was to ensure a flat surface so there would be no shadowing when the pads were run through the Spec*Scan 2000. After pressing, the pads were then air dried. These pads were used as the control, containing no surfactant and no hexadecane.

After making the control pads, it was time to run the agglomeration cells with the different surfactants. After consulting with a Buckman Laboratories representative, it was decided to evaluate the surfactants at three different levels. It was decided to run a low, medium, and high level, in which 1 #/ton would be the low, 3 #/ton would be the medium, and 5 #/ton would be the high. It was also decided at this time that the surfactants would be allowed to mix with the pulp for one hour to ensure enough time for the surfactants to act. The six jar stirrer was the mixing device used in this project to mix the surfactant and the hexadecane in with the pulp. It was used because it ensures uniform mixing in every run and is easily controlled.

A flow chart of part II of the experimental design is illustrated in Figure 1, on the following page. There were 24 different surfactant runs, and two control runs containing only different concentrations of hexadecane, for a total of 26 different runs. There were six different trials involving four different agglomerating cells and one trial involving only two agglomerating cells.

Run 1, 2, 3, and 4 consisted of placing 700 ml of pulp into a 2 liter beaker. The surfactants were then diluted down to 1% active indigent, using deionized water, to eliminate some of the analytical error in measuring (due to the fact that the amounts added were so small). After 700 ml of pulp was added to four different beakers (agglomerating

Figure 1 - Flowchart of Part II of the Experimental Design



cell), 0.42 g of each different surfactant was added to the corresponding beaker and placed in the six jar stirrer. The agglomerating cells were allowed to stir at 130 rpm for one hour. While the agglomerating cells were stirring, the hexadecane was diluted with deionized water to 1% and then homogenized in a drink mixer. Runs 1, 2, 3, and 4 consisted of using only 20 #/ton hexadecane. This came out to 8.4 grams of hexadecane per cell. This was added immediately following the one hour retention time. The hexadecane was added and allowed to stir at 130 rpm for one minute, to ensure uniform distribution. It was then slowed down to 40 rpm for 30 minutes to allow the agglomerates to form and float to the

top. After the thirty minute retention time, the cells were removed from the six jar stirrer and visual observations were made, with photographs being also taken for further comparison.

Once the observations and photographs were taken the cells were covered and allowed to sit for 24 hours to allow gravity settling to take place. Settling was the means of separating the fiber from the ink/oil agglomerates. After the cells were allowed to settle, visual observations were then recorded and addition photographs were taken. At this point the ink/oil agglomerates were removed from the surface. This was done by skimming them off with a 100 mesh screen. Once all of the byproduct was removed, brightness pads were made. Two pads were made from each cell weighing approximately 4 grams. The pads were then pressed in a British handsheet maker press for 20 minutes at 50 psig, which were then air dried. The pads were later used to determine dirt counts.

This process was repeated for runs 5-24, all containing the appropriate amounts of surfactant and hexadecane. Figure 2, on the proceeding page, illustrates all of different runs in table format. The procedure was slightly different for runs 26 and 27. This is due to the fact that they contained only hexadecane. Run 26 contained 20 #/ton hexadecane and run 27 contained 30 #/ton hexadecane. Due to this fact, the one hour retention time was not required. For these two runs, the required amount of hexadecane was initially added to 700 ml of pulp and placed in the six jar stirrer. The hexadecane was allowed to mix at 130 rpm for one minute and then slowed done to 40 rpm for thirty minutes, just as before. Observations, photographs and brightness pads were made in the same fashion as the previous runs. These two runs were used as comparisons to determines if the surfactant promoted any additional agglomeration over the hexadecane by itself.

Figure 2- Illustration of all the different runs in Part II of the Experimental Design in table format

20 #/ton

Surfactant	**BRD2340**	**BRD2342**	**Busperse 59**	**Busperse 47**
1 #/ton	Run 1	Run 2	Run 3	Run 4
3 #/ton	Run 5	Run 6	Run 7	Run 8
5 #/ton	Run 9	Run 10	Run 11	Run 12

0 #/ton	Run 27

30 #/ton

Surfactant	**BRD2340**	**BRD2342**	**Busperse 59**	**Busperse 47**
1 #/ton	Run 13	Run 14	Run 15	Run 16
3 #/ton	Run 17	Run 18	Run 19	Run 20
5 #/ton	Run 21	Run 22	Run 23	Run 24

0 #/ton	Run 26

Part III

Part three of the experimental design consisted of running the same stock through a standard air flotation cell. This was done so that a direct comparison between the two processes could be made. The flotation cell used in this experiment is the pilot flotation cell located in the basement of Western Michigan Universities Pilot Plant facility.

The flotation cell was run at 0.7% consistency, which amounted for a total of 218 grams of oven dried pulp. The pulp used was the same standard copy paper used in part II of the experimental design. It was printed on both sides with the same print as before, using the same type of ink. The pulping method of the stock was also the same as the pulping method discussed in part II of the experimental design.

The flotation cell was run at 100°F for 10 minutes. This was decided after talking with the pilot plant operators. It is the standard temperature and time for that particular deinking cell. The surfactant used in the flotation cell to induce foam was BRD2340. Typically, 2 #/ton surfactant are used in industry, however, it took approximately 3.5 #/ton of surfactant to induce adequate foam. There were no addition chemicals, other than BRD2340, added at any point in the flotation run.

After the flotation cell ran for ten minutes, the accepts were collected. Typically, the pulp is ran down a side hill screen to thicken the pulp back up to 3-4% consistency. However, this was not done due to the fact that I did not want to lose any ink left in the pulp after the flotation cell in the screening process. Just as before, two brightness pads were made in the same fashion as before to run through the Spec*Scan 2000.

After all of the pads from parts II and III were made and dried, they were run through the Spec*Scan 2000 to determine dirt counts. The instrument was set up according to the procedure, and left the same for all of the pads. The results of the test can be found in the results section of this report. The printouts produced by the Spec*Scan 2000 can be found in Appendix II.

Results

The results and data collected in the experimental design are listed in tables and illustrated in graphical form. Figure 3, below, present the dirt count data collected from the Spec*Scan 2000. The numbers in Figure 3 are the total number of specs detected by

Figure 3

Liquid Aggolmeration Dirt Count Data

Control (0 surfactant, 0 hexadecane) = 2357

20 #/ton hexadecane

	BRD2342	BRD2340	Busperse 47	Busperse 59
0 #/ton	2530	2530	2530	2530
1 #/ton	3664	3235	3378	2610
3 #/ton	2212	3361	2738	2779
5 #/ton	3423	2916	2472	2987

30 #/ton hexadecane

	BRD2342	BRD2340	Busperse 47	Busperse 59
0 #/ton	2907	2907	2907	2907
1 #/ton	3091	2756	2421	2755
3 #/ton	2721	3445	2215	2505
5 #/ton	2396	2328	2341	3114

Floatation Cell (BRD2342 used as surfactant)= 1672

the Spec*Scan 2000 in a six inch round pad larger than 0.04 mm^2. The runs containing 20 #/ton hexadecane are graphically illustrated in Figure 4 and the runs containing 30 #/ton hexadecane are graphically illustrated in Figure 5, on the following page. These graphs were produced to see if there was any relationship in the level of surfactant and amount of oil with amount of dirt in each pad. The pad with the lowest dirt count would theoretically be the cleanest, resulting in the best process.

Figure 5

The Effects of Different Surfactants on Dirt Count Using 30 #/ton Hexadecane

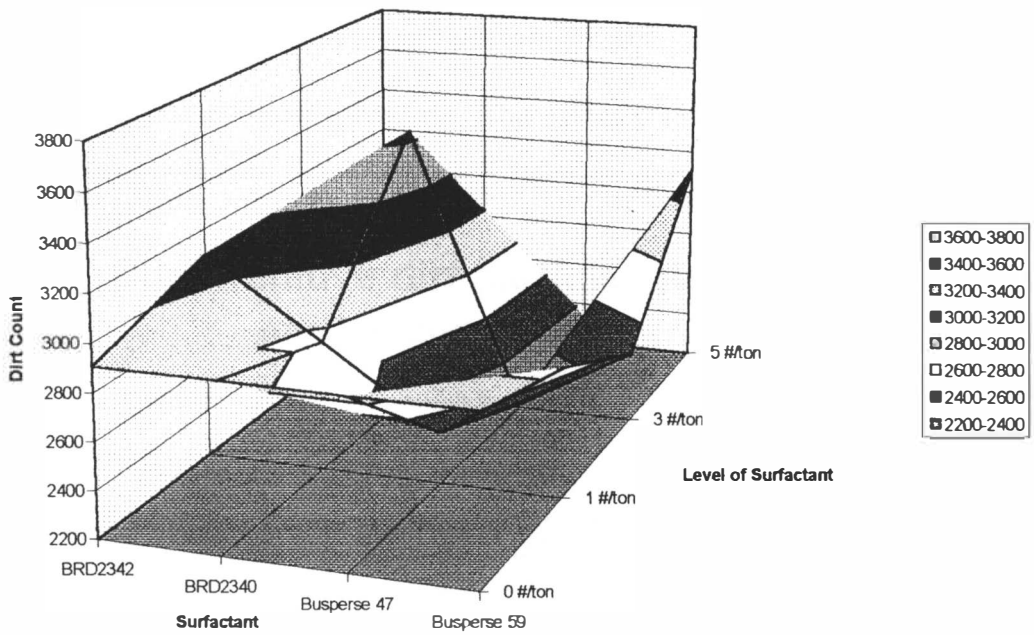


Figure 4

The Effects of Different Surfactants on Dirt Count Using 20 #/ton Hexadecane

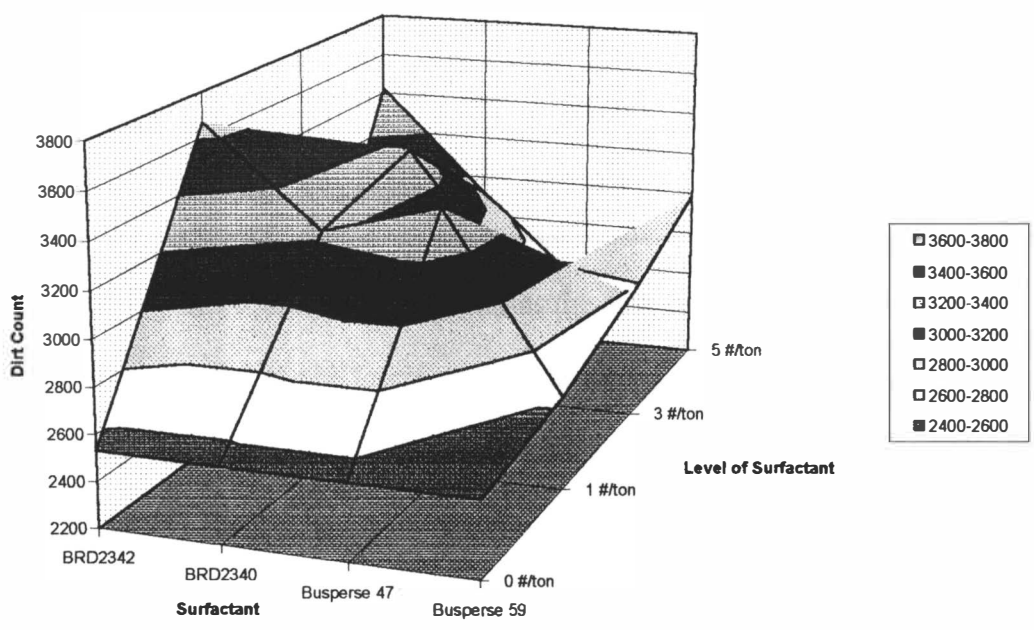


Figure 6, below, interrupts the data generated by the Spec*Scan slightly differently. All numbers presented in this table represent the particles larger than 0.4 mm^2 in PPM (parts per million). This represents all the large specs in the pads to see if there is a difference between the different operations. This data is graphically illustrated for

Figure 6

Cummulative dirt particles (in PPM) greater then 0.40 mm^2

Control (0 surfactant, 0 hexadecane) = 642.5

20 #/ton hexadecane

	BRD2342	BRD2340	Busperse 47	Busperse 59
0 #/ton	556.7	556.7	556.7	556.7
1 #/ton	3515.7	2962.5	1395.3	864.9
3 #/ton	645.1	1846.3	602.8	1684.8
5 #/ton	1483.6	1020.5	718.6	1257.2

30 #/ton hexadecane

	BRD2342	BRD2340	Busperse 47	Busperse 59
0 #/ton	1022.7	1022.7	1022.7	1022.7
1 #/ton	1905.7	712.5	548.3	1501.4
3 #/ton	1019.3	1402.9	460.7	789.1
5 #/ton	228.9	496.3	608.8	1340.9

Flotation cell = 213.4

20 #/ton in Figure 7. Figure 8 graphically illustrates the data in Figure 6 for 30 #/ton hexadecane. Figures 7 and 8 can be found on the following page. The data is presented this way so that one can see how the different surfactants, different levels of surfactants, and different amounts of hexadecane effect ink spec size.

Figure 7

The Effects of Surfactant Level on Dirt Specs Larger that 0.40 mm^2 in PPM.

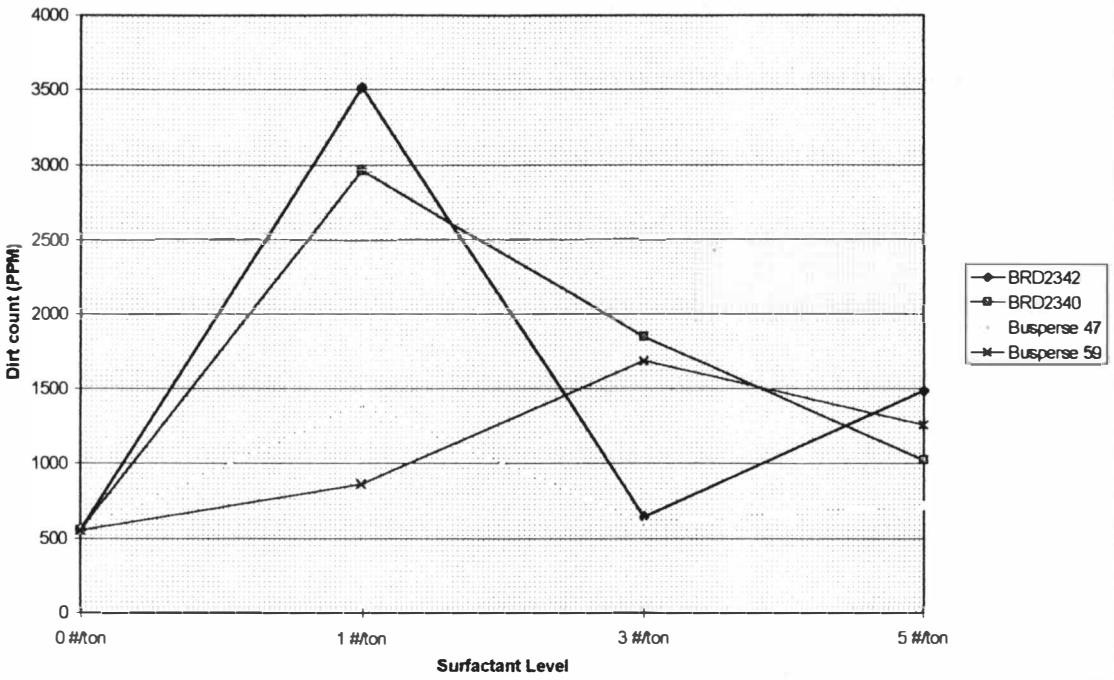
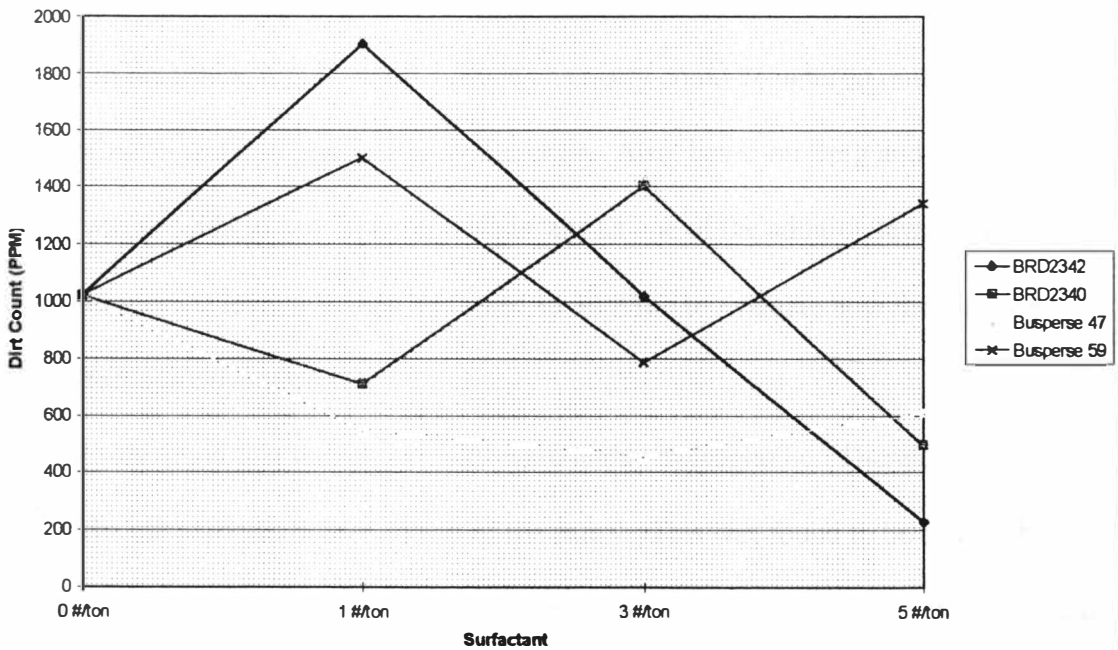


Figure 8

The Effects of Surfactant Level on Dirt Count for Specs Larger Than 0.40 mm^2 in PPM



Discussion

The first portion of experimental design was to evaluate whether or not the ink particles agglomerated with the hexadecane. It was observed that the ink particles attached to the dispersed oil in the water and did indeed agglomerate. It was also observed that small agglomerates formed at first, which then collided with other small agglomerates forming larger agglomerates. The agglomerates that were formed then rapidly rose to the surface. The agglomerates ranged from 0.4 to 0.8 mm in size. These observations corresponded to the observations made by Berg and Snyder in previous work (3). After concluding that hexadecane was an effective agglomerating oil, it was time to proceed with part II of the experimental design.

Part two of the experimental design was based on the findings by Berg and Synder at the University of Washington (3). They found that the internal size and internal starch of the paper inhibited the agglomeration process (3). This portion of the experiment was designed to determine if the correct surface chemistry could be induced onto the fiber, by the use of surfactants, to promote agglomeration. Also, based on Berg and Snyder's work, it was decided to use 20 #/ton hexadecane as one of the addition levels (3). The second hexadecane level was then increased to 30 #/ton to evaluate how the increase would effect agglomeration (3).

It was found that the ink particles were highly hydrophobic. Therefore, by nature, some of the ink particles floated to top of the slurry. This was found to be true in the control containing no surfactant or hexadecane, in which small ink particles were found to be floating on the top after settling. It was found in runs 26 and 27, that with the addition

of hexadecane, the ink on the surface tended to agglomerate into larger spherical balls, just as they did in the absence of fiber. It was also observed, in run 26, that with the increase in hexadecane the agglomerates became larger. However, there was a great deal of ink still entrained within the fiber slurry.

In runs 1-24, the use of four different surfactants were evaluated to see if they could enhance the agglomeration between hexadecane and the ink particles. The surfactants used were BRD2340, BRD2342, Busperse 47, and Busperse 59. BRD2340 and BRD2342 were chosen because they are collectors and are used to induce foam in the air flotation process. Busperse 47, and Busperse 59 were chosen because, according to the Buckman Laboratories representative, they are capable of offsetting the effects of internal size and internal starch on the fiber. The surfactants were evaluated at three different levels to see if the increase in surfactant would increase agglomeration between the hexadecane and the ink particles. Visual observations were taken after each of the runs. Photographs were also taken, however the pictures did not turn out due to the glare of the flash off of the water and glass of the agglomerating cells. This is why the photographs taken during the experimental design are not included in this report.

During the experiment, it was noticed that almost all of the agglomeration took place within the first ten minutes of mixing. This was true of all runs. It was also noticed that in the cells where large amounts of agglomeration took place, some of the agglomerates were so large that they sank back into the pulp slurry. This happened more with the cells containing 30 #/ton of hexadecane. This indicated that 30 #/ton of hexadecane exceeded the ideal addition level, and 20 #/ton of hexadecane was optimal.

For runs 1, 5, 9, 13, 17, and 21, BRD2340 was added in conjunction with hexadecane. Visually, it was observed that the use of BRD2340 in any amount or did not promote agglomeration. After comparing the runs using BRD2340 with runs 26 and 27, which contained only hexadecane, there was no noticeable differences at either level of hexadecane. The agglomeration which did occur, is believed to be caused by the inks nature affinity to separate from the water.

BRD2342 was used in runs 2, 6, 10, 14, 18, and 22. BRD2342 is another surfactant used in deinking as a collecting agent. Visually, it also did not appear to promote agglomeration in any of the runs. There were no noticeable differences observed between BRD2342 and runs containing only hexadecane. It was concluded that BRD2340 and BRD2342 did not alter the surface chemistry of the fiber to promote agglomeration.

Busperse 47 was another surfactant evaluated in this project. According to the Buckman Laboratory representative, it should eliminate internal size and internal starch. Runs 3, 7, 11, 15, 19, and 23 all contained Busperse 47. Runs 3, 7, and 11 contained 20 #/ton hexadecane with 1 #/ton, 3 #/ton, and 5 #/ton of Busperse 47, respectively. Visually, it was observed that as the level of surfactant increased, the level of agglomeration increased. It was noticed that there was still a great deal of ink entrained within the slurry. However, compared to runs 26 and 27, there was much more agglomeration occurring at the surface. It was concluded that Busperse 47 promoted the agglomeration between the ink particles and the hexadecane.

Busperse 59 was the last surfactant evaluated in this project. Runs 4, 8, 12, 16, 20, and 24 consisted of Busperse 59 and hexadecane. Runs 4, 8, and 12 contained 1 #/ton, 3 #/ton, and 5 #/ton of Busperse 59 in conjunction with 20 #/ton hexadecane. Runs 16, 20, and 24 contained 1 #/ton, 3 #/ton, and 5 #/ton of Busperse 59 in conjunction with 30 #/ton hexadecane. The agglomeration cells containing Busperse 59 visually displayed the largest degree of agglomeration. The largest degree of agglomeration occurred in the cells containing 5 #/ton of Busperse 59. Run 24 had the largest agglomerates formed, however, some of the agglomerates were so large the that the weight of the agglomerates overcame the buoyant force required to keep the particles afloat and the agglomerates sank. This is the reason the 20 #/ton of hexadecane was concluded early as being the ideal amount of oil.

After all of the agglomeration runs were complete, brightness pads were made and run through the Spec*Scan 2000 to determine dirt count. Theoretically, the pads containing the least amount of dirt should be the cleanest. This data is presented in tables and graphs in the results portion of the report.

In figure 3, the total amount of dirt larger than 0.04 mm^2 is presented in table form. Figures 4 and 5, graphically illustrates this data from the runs containing 20 #/ton hexadecane and 30 #/ton hexadecane, respectively. It can be seen in the graphs that there is no particular trend. If there was a distinct relationship between total amount of dirt and type and level of surfactant, there would be a smooth surface. However, this is not the case. The reason why this data does not support the visual observations made during the experiment is believed to be from two reasons. One of the reasons is because of the

amount of time required to make the pad. It took any where from 5 to 10 minutes to drain all of the water out of the pad. It was observed that while the pad was draining, the ink particles tended to float to the top. Therefore, remaining on the surface of the pad, which resulted in high dirt count numbers. The other reason why the analytical data and the visual observations do not support each other is believed to be because there was so much ink in the pulp slurry to begin with, that the amount of ink removed was not enough to show significant differences.

Another conclusion made from the data in figure 3 is that the agglomeration process is not as efficient at removing ink as the air flotation process. It can be seen in figure 3, that the pulp that was ran through the air flotation cell only reported a total dirt count of 1672 specs larger than 0.04 mm^2, whereas the agglomeration cells all reported numbers above 2000. In some cases, the agglomeration cells reported numbers above 3000. This indicates that the air flotation cell is more efficient at removing ink.

Another thing observed during the experiment was that the ink particles became larger in size in the agglomeration cell. This observation is supported by the data presented in figure 6. The data in figure 6 is graphically illustrated in figures 7 and 8 for the runs containing hexadecane. Figure 6 presents the amount of dirt counted larger than 0.40 mm^2. It can be seen that the air flotation cell reported 213 parts per million larger than 0.40 mm^2, whereas all of the agglomeration cells reported much higher amounts of large ink specs. From this data it can be concluded that the hexadecane is in fact agglomerating the ink particles, they just are not being removed.

After performing this experiment, some problems were identified. It is believed that if the agglomeration cells were run at a lower consistency, there would have been more ink removed. It was observed that there was a great deal of ink entrained within the fiber slurry, which could not float to the top. This experiment was run at 1.2% consistency, whereas it probably would have ran more efficiently between 0.5 and 0.7% consistency. Also, it is believed that altering the design of the agglomeration cell could increase agglomeration between the hexadecane and the ink particles. If the hexadecane could be injected into the bottom, as opposed to the top, it is believed there would be more oil ink interaction causing for more agglomeration.

It was concluded early that hexadecane did in fact agglomerate the ink particles. It is hypothesized that if the hexadecane was run in conjunction with an air flotation cell that more ink might possibly be removed due to the larger particles formed by agglomeration. This could be achieved by placing an agglomeration cell in between the pulping stage and the air flotation stage. The hexadecane could be injected into the agglomeration cell where agglomeration between the ink particles and the hexadecane could take place. The pulp could then be immediately pumped to a flotation cell where air would be injected into the cell for ink removal. It hypothesized that the larger particles would be more readily removed, thus enhancing the performance of the air flotation cell.

Conclusions

After performing this experiment, conclusions were made. The first thing concluded, in part 1 of experimental design, was that the ink particle did in fact agglomerate in the absence of fiber, and that hexadecane is an efficient agglomerating oil. In part II of the experiment, it was found that BRD2340 and BRD2342 did not promote agglomeration over that of hexadecane by itself. However, visually, Busperse 47 and Busperse 59 were found to promote agglomeration, with Busperse 59 performing the best. It also concluded that 20 #/ton hexadecane is the optimal level of oil addition. It was found, in the runs containing 30 #/ton hexadecane, that the agglomerates, in some cases, became so large that they sank back into the fiber slurry. During this experiment it was also found that the agglomeration process increased the size of the ink particles. This was evident both visually and analytically.

The last thing evaluated in this thesis project was whether or not the liquid agglomeration process could be used in place of an air flotation cell. It was concluded at this time that it could not, due to the fact that the liquid agglomeration process was unable to produce as clean a pulp as that of an air flotation cell. This was evident through the dirt counts performed on the Spec*Scan 2000.

Recommendations

It is believed that there were a few things that could have been done differently that might have improved this experiment. If the cells had been run at a lower consistency, more agglomeration might have taken place. The consistency for this experiment was 1.2%. It was observed that there was a great deal of ink entrained within the fiber slurry, which prevented any chance of them floating to the top. I would recommend running the cells between 0.5% and 0.7% consistency if it were to be repeated. Also, I would alter the agglomeration cell construction. I would inject the agglomerating oil in through the bottom, similar to that of an air flotation cell.. This way the agglomerating oil would pass through the entire slurry, allowing for more interaction between the hexadecane and the ink particles.

Another thing that I would possibly look into is running the hexadecane in conjunction with an air flotation cell. It is hypothesized that the larger particles would enhance the flotation process. I would do this by placing an agglomeration cell in between the pulping process and the flotation process. I would inject the hexadecane in the agglomeration cell for the purpose of increasing the ink particle size. I would then immediately run the pulp through the air flotation cell for ink removal.

One last recommendation is to not use a flash camera when photographing the results for further comparison. The glare caused by my camera off the water resulted in unusable photographs. I would construct a camera stand, ensuring that the photographs would be taken at the same distance. This would eliminate any distortion in appearance of

the agglomerates formed, caused by variations in distance and angle at which the camera was held.

References

1) Spangenberg, R.J., ed. **Secondary Fiber Recycling**. Tappi Press, Atlanta, GA. 1993.

2) Marchildon, L., Castro, C.C., Lapointe, M.W., and Daneault, C., *Evaluation of Carbon Dioxide as a Carrier Gas in Flotation Deinking.* **Tappi Journal.** 76(3): pp. 155-159.

3) Berg J.C., and Snyder, B.A., Liquid Bridge Agglomeration: A Fundamental Approach to Toner Deinking. **Tappi Journal** 77(7): pp. 79-84.

4) Israelachvili, J., **Intermolecular and Surface Forces**, 2nd edn., Academic Press, London, 1992, p. 315.

Appendix I: Sample Calculations

Repulping Method Part II Calculations:

700 ml slurry at 1.2% consistency

$\Rightarrow$ O.D. fiber = Consistency (Total Slurry)
= 0.12 (700)
O.D. fiber = **8.4 grams/jar**

Considering there is 27 total runs:

$\Rightarrow$ (8.4 grams/jar) x (27 jars) = 226.8 grams of O.D. fiber

Therefore to be safe: **250 grams of Oven dried fiber is required**

Repulp at 1.2% consistency

$\Rightarrow$ Total Slurry = $\frac{\text{O.D. Fiber}}{\text{Consistency}}$

$= \frac{250 \text{ grams}}{0.012} = 20833.3 \text{ ml} \approx$ **20 liters of Total Slurry**

Therefore there will be a total of 10 batches at 2 liters a piece

Repulping Method Part III Calculations

The air flotation cell requires 218 grams of O.D fiber

$\Rightarrow$ Total Slurry = $\frac{\text{O.D. Fiber}}{\text{Consistency}}$

$= \frac{218 \text{ grams}}{0.012} = 18{,}166.6 \text{ ml} = 18.2$ liters of total slurry

Air flotation cell needs to be run at approximately 0.7% consistency

$\Rightarrow$ Total Slurry = $\frac{\text{O.D. Fiber}}{\text{Consistency}} = \frac{218}{0.007} = 31{,}142.9 \text{ ml} = 31.1$ liters of slurry

$\Rightarrow 31.1 - 18.2 = 12.9$ liters of water to add to flotation cell after adding 18.2 liters of 1.2% slurry

Addition of Surfactant

Low = 1.0 #/ton

$$\frac{1\text{ lb}}{\text{ton}} \left| \frac{453.6\text{ g}}{1\text{ lb}} \right| \frac{1\text{ ton}}{907{,}184.7\text{ g}} = \frac{5.0 \times 10^{-4}\text{ grams surfactant}}{1.0\text{ grams of O.D. fiber}}$$

$$\Rightarrow \frac{5.0 \times 10^{-4}\text{ grams surfactant}}{1.0\text{ grams of O.D. fiber}} \left| \frac{8.4\text{ grams of O.D fiber}}{1\text{ jar}} \right.$$

$$= 0.0042\text{ grams surfactant/jar}$$

⇒ At 1% = 0.42 grams surfactant/jar

Medium = 3.0 #/ton

$$\frac{3\text{ lb}}{\text{ton}} \left| \frac{453.6\text{ g}}{1\text{ lb}} \right| \frac{1\text{ ton}}{907{,}184.7\text{ g}} = \frac{1.5 \times 10^{-3}\text{ grams surfactant}}{1.0\text{ grams of O.D. fiber}}$$

$$\Rightarrow \frac{1.5 \times 10^{-3}\text{ grams surfactant}}{1.0\text{ grams of O.D. fiber}} \left| \frac{8.4\text{ grams of O.D fiber}}{1\text{ jar}} \right.$$

$$= 0.0126\text{ grams surfactant/jar}$$

⇒ At 1% = 1.26 grams surfactant/jar

High = 5.0 #/ton

$$\frac{5\text{ lb}}{\text{ton}} \left| \frac{453.6\text{ g}}{1\text{ lb}} \right| \frac{1\text{ ton}}{907{,}184.7\text{ g}} = \frac{2.5 \times 10^{-3}\text{ grams surfactant}}{1.0\text{ grams of O.D. fiber}}$$

$$\Rightarrow \frac{2.5 \times 10^{-3}\text{ grams surfactant}}{1.0\text{ grams of O.D. fiber}} \left| \frac{8.4\text{ grams of O.D fiber}}{1\text{ jar}} \right.$$

$$= 0.0210\text{ grams surfactant/jar}$$

⇒ At 1% = 2.10 grams surfactant/jar

Addition of Hexadecane

20 #/ton

$$\frac{20\text{ lb}}{\text{ton}} \times \frac{453.6\text{ g}}{1\text{ lb}} \times \frac{1\text{ ton}}{907{,}184.7\text{ g}} \times \frac{0.100\text{ grams hexadecane}}{1.0\text{ grams of O.D. fiber}}$$

$$\Rightarrow \frac{0.100\text{ grams hexadecane}}{1.0\text{ grams of O.D. fiber}} \times \frac{8.4\text{ grams of O.D fiber}}{1\text{ jar}}$$

= 0.84 grams surfactant/jar

⇒ **At 1% = 8.4 grams hexadecane/jar**

30 #/ton

$$\frac{30\text{ lb}}{\text{ton}} \times \frac{453.6\text{ g}}{1\text{ lb}} \times \frac{1\text{ ton}}{907{,}184.7\text{ g}} \times \frac{0.150\text{ grams hexadecane}}{1.0\text{ grams of O.D. fiber}}$$

$$\Rightarrow \frac{0.150\text{ grams hexadecane}}{1.0\text{ grams of O.D. fiber}} \times \frac{8.4\text{ grams of O.D fiber}}{1\text{ jar}}$$

= 1.26 grams surfactant/jar

⇒ **At 1% = 12.6 grams hexadecane/jar**

Appendix II

Spec*Scan 2000 printouts

Western Michigan University

Spec*Scan 2000 - V.1.2.18

Fri 8-Nov-1996 14:51

Scanner Settings: Liquid Agglomeration, Tim Boven
Grade Identification: Busperse 59 5#/ton
Load / Reel Number: 30 #/ton Hexadecane

Resolution: 600 dots/inch
Threshold: 90 manual
White Level: 91
Black Level: 4
256-shade Grayscale mode

2 sheets 6-inch round
Total Area Scanned: 0.027536 sq.m.

Dirt Content Histogram	Dirt Spot Size	— Sample — Count	Area (sq.mm)	— Sample — Count (in 1 sq.meter)	PPM	— Cumulative — Count	Area (sq.mm)	Cum. PPM
	>= 5.000	0						
	4.00–5.00	0						
	3.00–4.00	0						
1	2.50–3.00	1	2.518	36	91.4	1	2.518	91.4
	2.00–2.50	0						
2	1.50–2.00	2	3.423	73	124.3	3	5.941	215.8
	1.00–1.50	0						
2	0.80–1.00	2	1.771	73	64.3	5	7.711	280.1
6	0.60–0.80	6	4.188	218	152.1	11	11.900	432.2
	0.40–0.60	52	25.023	1888	908.8	63	36.923	1340.9
	0.30–0.40	93	31.846	3377	1156.5	156	68.769	2497.4
	0.25–0.30	97	26.536	3523	963.7	253	95.305	3461.1
	0.20–0.25	154	34.240	5593	1243.5	407	129.545	4704.6
	0.15–0.20	240	41.108	8716	1492.9	647	170.653	6197.5
	0.10–0.15	509	61.504	18485	2233.6	1156	232.156	8431.1
	0.09–0.10	137	12.907	4975	468.7	1293	245.063	8899.8
	0.08–0.09	221	18.704	8026	679.3	1514	263.768	9579.1
	0.07–0.08	220	16.516	7990	599.8	1734	280.284	10178.9
	0.06–0.07	316	20.547	11476	746.2	2050	300.830	10925.1
	0.05–0.06	487	26.421	17686	959.5	2537	327.252	11884.6
	0.04–0.05	577	25.557	20955	928.2	3114	352.809	12812.8
	0.03–0.04	1003	34.606	36425	1256.8	4117	387.415	14069.5
	0.02–0.03	1325	32.762	48119	1189.8	5442	420.176	15259.3
	0.01–0.02	3194	45.918	115995	1667.6	8636	466.094	16926.9
	0.005–0.01	3394	23.665	123258	859.4	12030	489.759	17786.3
	< 0.005	4958	12.409	180057	450.6	16988	502.168	18236.9
30	Totals ->	16988	502.168	616943	18236.9			

Categories:	Min Avg. Gray	Max Avg. Gray	Min Meas. Area	Max Meas. Area	Count	Area (sq.mm)	— Calculated — Count (in 1 sq.meter)	PPM	Average Grayscale	Darkest Grayscale	Average Size (sq.mm)
Total >=0.04 sq.mm.	0	255	0.040	99999	3114	352.809	113089	12812.8	63.76	12.00	0.113
Very Dark >= 0.04	0	60	0.040	99999	1233	176.832	44778	6421.9	53.21	12.00	0.143
Medium Dark	60	90	0.040	99999	1985	186.694	72088	6780.1	70.12	16.00	0.094
Light	90	255	0.040	99999							
Total 0.02–0.04	0	255	0.020	0.040	2328	67.368	84545	2446.5	70.01	29.00	0.029
Very Dark	0	60	0.020	0.040	333	10.353	12093	376.0	57.40	29.00	0.031
Medium Dark	60	90	0.020	0.040	2049	58.703	74412	2131.9	71.79	32.00	0.029
Light	90	255	0.020	0.040							
Total <0.04	0	255	0.000	0.040	13874	149.359	503854	5424.2	78.66	29.00	0.011

Sample Grayscale Brightness Analysis:

	99% Min	Mode	99% Max
Dirt Content:	23	89	90
Fiber Content:	102	179	217
Overall	70	179	220

Overall Grayscale Brightness = 172.6 = 67.7%
Overall Grayscale Std Deviation = 25.6 = 10.1%
Std.Dev. of Sheet Overall Ave. = 1.2 = 0.5%

Dirt Count Summary:

	All Sizes	>=0.040
Number of Specks:	16988	3114
Total Area (sq.mm):	502.17	352.81
Parts Per Million:	18236.9	12812.8
StdDev of Sheet PPM:	1361.94	1087.10
Count in 1 sq.m:	616943	113089
Counting Precision:	0.77	1.79

Western Michigan University

Spec*Scan 2000 - V.1.2.18

Fri 8-Nov-1996 15:23

Scanner Settings: Liquid Agglomeration, Tim Boven
Grade Identification: Busperse 59 3#/ton
Load / Reel Number: 30 #/ton Hexadecane

Resolution: 600 dots/inch
Threshold: 90 manual
White Level: 91
Black Level: 4
256-shade Grayscale mode

2 sheets 6-inch round
Total Area Scanned: 0.027536 sq.m.

Dirt Content Histogram	Dirt Spot Size	— Sample — Count	Area (sq.mm)	— Sample — Count (in 1 sq.meter)	PPM	— Cumulative — Count	Area (sq.mm)	Cum. PPM
	>= 5.000	0						
	4.00–5.00	0						
	3.00–4.00	0						
	2.50–3.00	0						
	2.00–2.50	0						
1	1.50–2.00	1	1.943	36	70.6	1	1.943	70.6
	1.00–1.50	0						
1	0.80–1.00	1	0.862	36	31.3	2	2.805	101.9
4	0.60–0.80	4	2.645	145	96.1	6	5.450	197.9
	0.40–0.60	35	16.280	1271	591.2	41	21.729	789.1
	0.30–0.40	63	21.584	2288	783.9	104	43.314	1573.0
	0.25–0.30	70	19.156	2542	695.7	174	62.470	2268.7
	0.20–0.25	113	25.181	4104	914.5	287	87.651	3183.2
	0.15–0.20	217	37.267	7881	1353.4	504	124.918	4536.6
	0.10–0.15	419	50.312	15217	1827.1	923	175.230	6363.7
	0.09–0.10	118	11.185	4285	406.2	1041	186.414	6769.9
	0.08–0.09	174	14.783	6319	536.9	1215	201.198	7306.8
	0.07–0.08	179	13.479	6501	489.5	1394	214.676	7796.3
	0.06–0.07	291	18.975	10568	689.1	1685	233.651	8485.4
	0.05–0.06	378	20.618	13728	748.8	2063	254.269	9234.1
	0.04–0.05	442	19.690	16052	715.1	2505	273.959	9949.2
	0.03–0.04	864	29.891	31377	1085.5	3369	303.850	11034.7
	0.02–0.03	1195	29.500	43398	1071.3	4564	333.350	12106.1
	0.01–0.02	2770	40.077	100596	1455.5	7334	373.427	13561.5
	0.005–0.01	2963	20.522	107606	745.3	10297	393.949	14306.8
30	< 0.005	4492	11.340	163133	411.8	14789	405.289	14718.7
	Totals ->	14789	405.289	537083	14718.7			

Categories:	Min Avg. Gray	Max Avg. Gray	Min Meas. Area	Max Meas. Area	Count	Area (sq.mm)	— Calculated — Count (in 1 sq.meter)	PPM	Average Grayscale	Darkest Grayscale	Average Size (sq.mm)
Total >=0.04 sq.mm.	0	255	0.040	99999	2505	273.959	90973	9949.2	64.06	14.00	0.109
Very Dark >= 0.04	0	60	0.040	99999	926	130.187	33629	4727.9	52.97	14.00	0.141
Medium Dark	60	90	0.040	99999	1655	151.541	60104	5503.4	70.08	19.00	0.092
Light	90	255	0.040	99999							
Total 0.02–0.04	0	255	0.020	0.040	2059	59.391	74775	2156.9	70.34	28.00	0.029
Very Dark	0	60	0.020	0.040	282	8.803	10241	319.7	57.67	28.00	0.031
Medium Dark	60	90	0.020	0.040	1849	52.781	67149	1916.8	71.87	32.00	0.029
Light	90	255	0.020	0.040							
Total <0.04	0	255	0.000	0.040	12284	131.330	446111	4769.4	78.63	28.00	0.011

Sample Grayscale Brightness Analysis:

	99% Min	Mode	99% Max
Dirt Content:	23	90	90
Fiber Content:	105	189	216
Overall	76	189	219

Overall Grayscale Brightness = 178.9 = 70.2%
Overall Grayscale Std Deviation = 24.0 = 9.4%
Std.Dev. of Sheet Overall Ave. = 4.5 = 1.8%

Dirt Count Summary:

	All Sizes	>=0.040
Number of Specks:	14789	2505
Total Area (sq.mm):	405.29	273.96
Parts Per Million:	14718.7	9949.2
StdDev of Sheet PPM:	219.15	88.27
Count in 1 sq.m:	537083	90973
Counting Precision:	0.82	2.00

Western Michigan University

Spec*Scan 2000 - V.1.2.18

Fri 8-Nov-1996 11:49

Scanner Settings: Liquid Agglomeration, Tim Boven
Grade Identification: Busperse 59 1#/ton
Load / Reel Number: 30 #/ton hexadecane

Resolution: 600 dots/inch
Threshold: 90 manual
White Level: 91
Black Level: 4
256-shade Grayscale mode

2 sheets 6-inch round
Total Area Scanned: 0.027536 sq.m.

Dirt Content Histogram	Dirt Spot Size	— Sample — Count	Area (sq.mm)	— Sample — Count (in 1 sq.meter)	PPM	— Cumulative — Count	Area (sq.mm)	Cum. PPM
	>= 5.000	0						
	4.00–5.00	0						
	3.00–4.00	0						
	2.50–3.00	0						
1	2.00–2.50	1	2.190	36	79.5	1	2.190	79.5
	1.50–2.00	0						
4	1.00–1.50	4	4.948	145	179.7	5	7.138	259.2
1	0.80–1.00	1	0.810	36	29.4	6	7.948	288.6
11	0.60–0.80	11	7.502	399	272.4	17	15.450	561.1
	0.40–0.60	56	25.893	2034	940.3	73	41.342	1501.4
	0.30–0.40	77	26.022	2796	945.0	150	67.364	2446.4
	0.25–0.30	76	20.857	2760	757.4	226	88.221	3203.9
	0.20–0.25	115	25.799	4176	936.9	341	114.020	4140.8
	0.15–0.20	229	39.104	8316	1420.1	570	153.124	5560.9
	0.10–0.15	476	57.738	17287	2096.9	1046	210.862	7657.8
	0.09–0.10	137	13.030	4975	473.2	1183	223.893	8131.0
	0.08–0.09	182	15.536	6610	564.2	1365	239.429	8695.2
	0.07–0.08	199	14.905	7227	541.3	1564	254.334	9236.5
	0.06–0.07	315	20.529	11440	745.5	1879	274.863	9982.0
	0.05–0.06	380	20.720	13800	752.5	2259	295.583	10734.5
	0.04–0.05	496	22.066	18013	801.4	2755	317.649	11535.9
	0.03–0.04	914	31.504	33193	1144.1	3669	349.153	12680.0
	0.02–0.03	1262	31.117	45831	1130.0	4931	380.270	13810.0
	0.01–0.02	3106	45.063	112799	1636.5	8037	425.332	15446.5
	0.005–0.01	3286	22.954	119336	833.6	11323	448.286	16280.1
	< 0.005	4796	11.987	174174	435.3	16119	460.274	16715.5
30	Totals ->	16119	460.274	585384	16715.5			

Categories:	Min Avg. Gray	Max Avg. Gray	Min Meas. Area	Max Meas. Area	Count	Area (sq.mm)	— Calculated — Count (in 1 sq.meter)	PPM	Average Grayscale	Darkest Grayscale	Average Size (sq.mm)
Total >=0.04 sq.mm.	0	255	0.040	99999	2755	317.649	100052	11535.9	61.97	14.00	0.115
Very Dark >= 0.04	0	60	0.040	99999	1293	182.999	46957	6645.9	52.67	14.00	0.142
Medium Dark	60	90	0.040	99999	1552	143.814	56363	5222.8	69.61	20.00	0.093
Light	90	255	0.040	99999							
Total 0.02–0.04	0	255	0.020	0.040	2176	62.620	79025	2274.1	68.30	21.00	0.029
Very Dark	0	60	0.020	0.040	418	12.711	15180	461.6	57.14	21.00	0.030
Medium Dark	60	90	0.020	0.040	1839	52.308	66786	1899.7	70.47	30.00	0.028
Light	90	255	0.020	0.040							
Total <0.04	0	255	0.000	0.040	13364	142.624	485332	5179.6	77.45	21.00	0.011

Sample Grayscale Brightness Analysis:

	99% Min	Mode	99% Max
Dirt Content:	22	90	90
Fiber Content:	106	190	209
Overall	71	190	211

Overall Grayscale Brightness = 178.7 = 70.1%
Overall Grayscale Std Deviation = 23.6 = 9.3%
Std.Dev. of Sheet Overall Ave. = 1.0 = 0.4%

Dirt Count Summary:

	All Sizes	>=0.040
Number of Specks:	16119	2755
Total Area (sq.mm):	460.27	317.65
Parts Per Million:	16715.5	11535.9
StdDev of Sheet PPM:	1638.53	1521.82
Count in 1 sq.m:	585384	100052
Counting Precision:	0.79	1.91

Western Michigan University

Spec*Scan 2000 - V.1.2.18

Fri 8-Nov-1996 15:06

Scanner Settings: Liquid Agglomeration, Tim Boven
Grade Identification: Busperse 47 5#/ton
Load / Reel Number: 30 #/ton Hexadecane

Resolution: 600 dots/inch
Threshold: 90 manual
White Level: 91
Black Level: 4
256-shade Grayscale mode

2 sheets 6-inch round
Total Area Scanned: 0.027536 sq.m.

Dirt Content Histogram	Dirt Spot Size	Sample Count	Sample Area (sq.mm)	Sample Count (in 1 sq.meter)	Sample PPM	Cumulative Count	Cumulative Area (sq.mm)	Cumulative Cum. PPM
	>= 5.000	0						
	4.00–5.00	0						
	3.00–4.00	0						
	2.50–3.00	0						
	2.00–2.50	0						
	1.50–2.00	0						
	1.00–1.50	0						
	0.80–1.00	0						
2	0.60–0.80	2	1.371	73	49.8	2	1.371	49.8
34	0.40–0.60	34	15.393	1235	559.0	36	16.763	608.8
	0.30–0.40	45	15.409	1634	559.6	81	32.172	1168.4
	0.25–0.30	67	18.362	2433	666.8	148	50.534	1835.2
	0.20–0.25	121	27.018	4394	981.2	269	77.552	2816.4
	0.15–0.20	172	29.652	6246	1076.9	441	107.204	3893.3
	0.10–0.15	399	48.106	14490	1747.0	840	155.310	5640.3
	0.09–0.10	92	8.686	3341	315.5	932	163.997	5955.8
	0.08–0.09	168	14.276	6101	518.5	1100	178.273	6474.2
	0.07–0.08	164	12.330	5956	447.8	1264	190.603	6922.0
	0.06–0.07	267	17.461	9696	634.1	1531	208.063	7556.1
	0.05–0.06	383	20.778	13909	754.6	1914	228.841	8310.7
	0.04–0.05	427	19.030	15507	691.1	2341	247.871	9001.8
	0.03–0.04	800	27.753	29053	1007.9	3141	275.624	10009.7
	0.02–0.03	1180	29.229	42853	1061.5	4321	304.854	11071.2
	0.01–0.02	2888	41.618	104882	1511.4	7209	346.472	12582.6
	0.005–0.01	3314	23.022	120353	836.1	10523	369.494	13418.7
30	< 0.005	5037	12.548	182926	455.7	15560	382.042	13874.4
	Totals ->	15560	382.042	565083	13874.4			

Categories:	Min Avg. Gray	Max Avg. Gray	Min Meas. Area	Max Meas. Area	Count	Area (sq.mm)	Calculated Count (in 1 sq.meter)	Calculated PPM	Average Grayscale	Darkest Grayscale	Average Size (sq.mm)
Total >=0.04 sq.mm.	0	255	0.040	99999	2341	247.871	85017	9001.8	64.50	16.00	0.106
Very Dark >= 0.04	0	60	0.040	99999	837	112.498	30397	4085.5	53.54	16.00	0.134
Medium Dark	60	90	0.040	99999	1590	143.891	57743	5225.6	70.02	21.00	0.090
Light	90	255	0.040	99999							
Total 0.02–0.04	0	255	0.020	0.040	1980	56.982	71906	2069.4	70.59	28.00	0.029
Very Dark	0	60	0.020	0.040	267	8.269	9696	300.3	57.26	28.00	0.031
Medium Dark	60	90	0.020	0.040	1766	50.283	64135	1826.1	72.29	31.00	0.028
Light	90	255	0.020	0.040							
Total <0.04	0	255	0.000	0.040	13219	134.170	480067	4872.6	79.00	28.00	0.010

Sample Grayscale Brightness Analysis:

	99% Min	Mode	99% Max
Dirt Content:	24	89	90
Fiber Content:	105	183	216
Overall	78	183	218

Overall Grayscale Brightness = 177.2 = 69.5%
Overall Grayscale Std Deviation = 23.5 = 9.2%
Std.Dev. of Sheet Overall Ave. = 2.1 = 0.8%

Dirt Count Summary:

	All Sizes	>=0.040
Number of Specks:	15560	2341
Total Area (sq.mm):	382.04	247.87
Parts Per Million:	13874.4	9001.8
StdDev of Sheet PPM:	951.62	534.03
Count in 1 sq.m:	565083	85017
Counting Precision:	0.80	2.07

Western Michigan University

Spec*Scan 2000 - V.1.2.18

Fri 8-Nov-1996 14:58

Scanner Settings: Liquid Agglomeration, Tim Boven
Grade Identification: Busperse 47 3#/ton
Load / Reel Number: 30 #/ton Hexadecane

Resolution: 600 dots/inch
Threshold: 90 manual
White Level: 91
Black Level: 4
256-shade Grayscale mode

2 sheets 6-inch round
Total Area Scanned: 0.027536 sq.m.

Dirt Content Histogram	Dirt Spot Size	Sample Count	Sample Area (sq.mm)	Sample Count (in 1 sq.meter)	Sample PPM	Cumulative Count	Cumulative Area (sq.mm)	Cumulative Cum. PPM
	>= 5.000	0						
	4.00–5.00	0						
	3.00–4.00	0						
	2.50–3.00	0						
	2.00–2.50	0						
	1.50–2.00	0						
	1.00–1.50	0						
	0.80–1.00	0						
3	0.60–0.80	3	1.916	109	69.6	3	1.916	69.6
23	0.40–0.60	23	10.769	835	391.1	26	12.685	460.7
35	0.30–0.40	35	11.871	1271	431.1	61	24.556	891.8
76	0.25–0.30	76	20.548	2760	746.2	137	45.104	1638.0
103	0.20–0.25	103	22.794	3741	827.8	240	67.898	2465.8
177	0.15–0.20	177	30.688	6428	1114.5	417	98.586	3580.3
345	0.10–0.15	345	41.548	12529	1508.9	762	140.135	5089.2
117	0.09–0.10	117	11.160	4249	405.3	879	151.294	5494.5
160	0.08–0.09	160	13.606	5811	494.1	1039	164.900	5988.6
166	0.07–0.08	166	12.430	6029	451.4	1205	177.330	6440.0
233	0.06–0.07	233	15.170	8462	550.9	1438	192.500	6990.9
353	0.05–0.06	353	19.222	12820	698.1	1791	211.723	7689.0
424	0.04–0.05	424	18.964	15398	688.7	2215	230.687	8377.7
827	0.03–0.04	827	28.638	30034	1040.0	3042	259.325	9417.7
1179	0.02–0.03	1179	29.084	42817	1056.2	4221	288.409	10474.0
3007	0.01–0.02	3007	43.015	109203	1562.1	7228	331.424	12036.1
3401	0.005–0.01	3401	23.680	123512	860.0	10629	355.103	12896.1
5243	< 0.005	5243	13.138	190407	477.1	15872	368.241	13373.2
30	Totals ->	15872	368.241	576414	13373.2			

Categories:	Min Avg. Gray	Max Avg. Gray	Min Meas. Area	Max Meas. Area	Count	Area (sq.mm)	Calculated Count (in 1 sq.meter)	Calculated PPM	Average Grayscale	Darkest Grayscale	Average Size (sq.mm)
Total >=0.04 sq.mm.	0	255	0.040	99999	2215	230.687	80441	8377.7	63.76	17.00	0.104
Very Dark >= 0.04	0	60	0.040	99999	847	107.911	30760	3918.9	53.20	17.00	0.127
Medium Dark	60	90	0.040	99999	1430	129.959	51932	4719.6	69.86	22.00	0.091
Light	90	255	0.040	99999							
Total 0.02–0.04	0	255	0.020	0.040	2006	57.722	72851	2096.3	69.40	26.00	0.029
Very Dark	0	60	0.020	0.040	334	10.301	12130	374.1	57.44	26.00	0.031
Medium Dark	60	90	0.020	0.040	1749	49.737	63517	1806.3	71.27	33.00	0.028
Light	90	255	0.020	0.040							
Total <0.04	0	255	0.000	0.040	13657	137.554	495973	4995.5	78.13	26.00	0.010

Sample Grayscale Brightness Analysis:

	99% Min	Mode	99% Max
Dirt Content:	25	90	90
Fiber Content:	106	190	216
Overall	79	190	218

Overall Grayscale Brightness = 180.7 = 70.9%
Overall Grayscale Std Deviation = 23.2 = 9.1%
Std.Dev. of Sheet Overall Ave. = 1.5 = 0.6%

Dirt Count Summary:

	All Sizes	>=0.040
Number of Specks:	15872	2215
Total Area (sq.mm):	368.24	230.69
Parts Per Million:	13373.2	8377.7
StdDev of Sheet PPM:	425.42	319.84
Count in 1 sq.m:	576414	80441
Counting Precision:	0.79	2.12

Western Michigan University

Spec*Scan 2000 - V.1.2.18

Fri 1-Nov-1996 18:30

Scanner Settings: Liquid Agglomeration, Tim Boven
Grade Identification: 1 #/ton Busperse 47
Load / Reel Number: 30 #/ton Hexadecane

Resolution: 600 dots/inch
Threshold: 90 manual
White Level: 91
Black Level: 4
256-shade Grayscale mode

2 sheets 6-inch round
Total Area Scanned: 0.027536 sq.m.

Dirt Content Histogram	Dirt Spot Size	Sample Count	Sample Area (sq.mm)	Sample Count (in 1 sq.meter)	Sample PPM	Cumulative Count	Cumulative Area (sq.mm)	Cumulative Cum. PPM
	>= 5.000	0						
	4.00–5.00	0						
	3.00–4.00	0						
	2.50–3.00	0						
	2.00–2.50	0						
	1.50–2.00	0						
	1.00–1.50	0						
	0.80–1.00	0						
6	0.60–0.80	6	4.084	218	148.3	6	4.084	148.3
23	0.40–0.60	23	11.013	835	399.9	29	15.097	548.3
62	0.30–0.40	62	21.031	2252	763.8	91	36.127	1312.0
65	0.25–0.30	65	17.812	2361	646.9	156	53.939	1958.9
119	0.20–0.25	119	26.222	4322	952.3	275	80.161	2911.2
195	0.15–0.20	195	33.785	7082	1227.0	470	113.946	4138.1
383	0.10–0.15	383	46.301	13909	1681.5	853	160.248	5819.6
122	0.09–0.10	122	11.590	4431	420.9	975	171.837	6240.5
147	0.08–0.09	147	12.450	5339	452.1	1122	184.287	6692.6
174	0.07–0.08	174	13.095	6319	475.6	1296	197.382	7168.2
252	0.06–0.07	252	16.461	9152	597.8	1548	213.843	7766.0
399	0.05–0.06	399	21.742	14490	789.6	1947	235.585	8555.6
474	0.04–0.05	474	21.210	17214	770.3	2421	256.794	9325.8
918	0.03–0.04	918	31.819	33338	1155.6	3339	288.613	10481.4
1266	0.02–0.03	1266	31.179	45977	1132.3	4605	319.793	11613.7
3103	0.01–0.02	3103	44.810	112690	1627.3	7708	364.603	13241.1
3384	0.005–0.01	3384	23.429	122895	850.8	11092	388.032	14091.9
4825	< 0.005	4825	12.149	175227	441.2	15917	400.180	14533.1
30	Totals ->	15917	400.180	578048	14533.1			

Categories:	Min Avg. Gray	Max Avg. Gray	Min Meas. Area	Max Meas. Area	Count	Area (sq.mm)	Calculated Count (in 1 sq.meter)	Calculated PPM	Average Grayscale	Darkest Grayscale	Average Size (sq.mm)
Total >=0.04 sq.mm.	0	255	0.040	99999	2421	256.794	87922	9325.8	63.58	16.00	0.106
Very Dark >= 0.04	0	60	0.040	99999	934	124.274	33920	4513.2	53.26	16.00	0.133
Medium Dark	60	90	0.040	99999	1569	140.706	56980	5109.9	69.53	22.00	0.090
Light	90	255	0.040	99999							
Total 0.02–0.04	0	255	0.020	0.040	2184	62.998	79315	2287.9	69.86	26.00	0.029
Very Dark	0	60	0.020	0.040	290	9.007	10532	327.1	57.25	26.00	0.031
Medium Dark	60	90	0.020	0.040	1963	56.034	71289	2035.0	71.37	32.00	0.029
Light	90	255	0.020	0.040							
Total <0.04	0	255	0.000	0.040	13496	143.386	490126	5207.2	78.40	26.00	0.011

Sample Grayscale Brightness Analysis:

	99% Min	Mode	99% Max
Dirt Content:	24	90	90
Fiber Content:	105	189	215
Overall	77	189	217

Overall Grayscale Brightness = 178.8 = 70.1%
Overall Grayscale Std Deviation = 23.6 = 9.3%
Std.Dev. of Sheet Overall Ave. = 1.8 = 0.7%

Dirt Count Summary:

	All Sizes	>=0.040
Number of Specks:	15917	2421
Total Area (sq.mm):	400.18	256.79
Parts Per Million:	14533.1	9325.8
StdDev of Sheet PPM:	973.80	437.84
Count in 1 sq.m:	578048	87922
Counting Precision:	0.79	2.03

Western Michigan University

Spec*Scan 2000 - V.1.2.18

Fri 8-Nov-1996 15:31

Scanner Settings: Liquid Agglomeration, Tim Boven
Grade Identification: BRD2342 5#/ton
Load / Reel Number: 30 #/ton Hexadecane

Resolution: 600 dots/inch
Threshold: 90 manual
White Level: 91
Black Level: 4
256-shade Grayscale mode

2 sheets 6-inch round
Total Area Scanned: 0.027536 sq.m.

Dirt Content Histogram	Dirt Spot Size	Sample Count	Sample Area (sq.mm)	Sample Count (in 1 sq.meter)	Sample PPM	Cumulative Count	Cumulative Area (sq.mm)	Cumulative Cum. PPM
	>= 5.000	0						
	4.00–5.00	0						
	3.00–4.00	0						
	2.50–3.00	0						
	2.00–2.50	0						
	1.50–2.00	0						
	1.00–1.50	0						
1	0.80–1.00	1	0.935	36	34.0	1	0.935	34.0
2	0.60–0.80	2	1.242	73	45.1	3	2.177	79.1
9	0.40–0.60	9	4.125	327	149.8	12	6.303	228.9
	0.30–0.40	54	18.880	1961	685.7	66	25.183	914.6
	0.25–0.30	52	14.199	1888	515.7	118	39.382	1430.2
	0.20–0.25	95	21.244	3450	771.5	213	60.626	2201.7
	0.15–0.20	175	30.258	6355	1098.9	388	90.884	3300.6
	0.10–0.15	371	45.360	13473	1647.3	759	136.244	4947.9
	0.09–0.10	99	9.360	3595	339.9	858	145.604	5287.8
	0.08–0.09	155	13.133	5629	476.9	1013	158.737	5764.8
	0.07–0.08	200	15.088	7263	547.9	1213	173.825	6312.7
	0.06–0.07	301	19.584	10931	711.2	1514	193.409	7023.9
	0.05–0.06	394	21.400	14309	777.2	1908	214.809	7801.1
	0.04–0.05	488	21.677	17722	787.2	2396	236.486	8588.3
	0.03–0.04	1004	34.624	36462	1257.4	3400	271.110	9845.7
	0.02–0.03	1319	32.690	47901	1187.2	4719	303.800	11032.9
	0.01–0.02	3567	51.620	129541	1874.7	8286	355.420	12907.6
	0.005–0.01	4199	29.106	152493	1057.0	12485	384.527	13964.6
	< 0.005	6382	15.910	231771	577.8	18867	400.437	14542.4
30	Totals ->	18867	400.437	685182	14542.4			

Categories:	Min Avg. Gray	Max Avg. Gray	Min Meas. Area	Max Meas. Area	Count	Area (sq.mm)	Calculated Count (in 1 sq.meter)	Calculated PPM	Average Grayscale	Darkest Grayscale	Average Size (sq.mm)
Total >=0.04 sq.mm.	0	255	0.040	99999	2396	236.486	87014	8588.3	62.43	17.00	0.099
Very Dark >= 0.04	0	60	0.040	99999	1051	122.025	38169	4431.5	53.20	17.00	0.116
Medium Dark	60	90	0.040	99999	1420	120.590	51569	4379.4	69.13	23.00	0.085
Light	90	255	0.040	99999							
Total 0.02–0.04	0	255	0.020	0.040	2323	67.314	84363	2444.6	67.82	28.00	0.029
Very Dark	0	60	0.020	0.040	434	13.416	15761	487.2	57.16	28.00	0.031
Medium Dark	60	90	0.020	0.040	1974	56.380	71689	2047.5	69.82	31.00	0.029
Light	90	255	0.020	0.040							
Total <0.04	0	255	0.000	0.040	16471	163.950	598168	5954.1	77.66	28.00	0.010

Sample Grayscale Brightness Analysis:

	99% Min	Mode	99% Max
Dirt Content:	24	90	90
Fiber Content:	105	186	210
Overall	76	186	212

Overall Grayscale Brightness = 176.5 = 69.2%
Overall Grayscale Std Deviation = 22.9 = 9.0%
Std.Dev. of Sheet Overall Ave. = 0.6 = 0.3%

Dirt Count Summary:

	All Sizes	>=0.040
Number of Specks:	18867	2396
Total Area (sq.mm):	400.44	236.49
Parts Per Million:	14542.4	8588.3
StdDev of Sheet PPM:	209.76	250.26
Count in 1 sq.m:	685182	87014
Counting Precision:	0.73	2.04

Western Michigan University

Spec*Scan 2000 - V.1.2.18

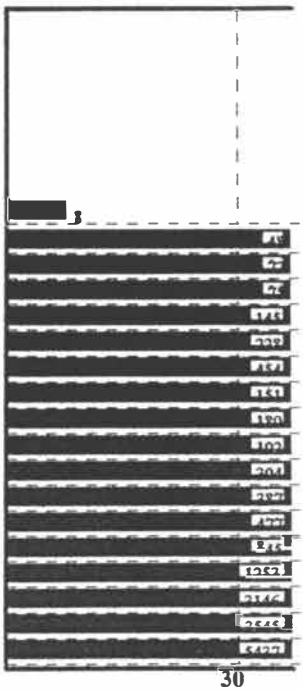
Fri 8-Nov-1996 1

Scanner Settings: Liquid Agglomeration, Tim Boven
Grade Identification: BRD2342 3#/ton
Load / Reel Number: 30 #/ton Hexadecane

Resolution: 600 d
Threshold: 90 ma
White Level: 9
Black Level: 4
256-shade Graysca

2 sheets 6-inch round
Total Area Scanned: 0.027536 sq.m.

Dirt Content Histogram



Dirt Spot Size	Sample Count	Sample Area (sq.mm)	Sample Count (in 1 sq.meter)	Sample PPM	Cumulati Count	Cumulati Area (sq.mm)	
>= 5.000	0						
4.00–5.00	0						
3.00–4.00	0						
2.50–3.00	0						
2.00–2.50	0						
1.50–2.00	0						
1.00–1.50	0						
0.80–1.00	0						
0.60–0.80	8	5.233	291	190.0	8	5.233	
0.40–0.60	48	22.833	1743	829.2	56	28.066	
0.30–0.40	72	24.803	2615	900.8	128	52.869	
0.25–0.30	75	20.421	2724	741.6	203	73.290	
0.20–0.25	145	32.410	5266	1177.0	348	105.701	
0.15–0.20	228	39.255	8280	1425.6	576	144.955	
0.10–0.15	454	55.099	16488	2001.0	1030	200.054	
0.09–0.10	151	14.323	5484	520.1	1181	214.377	
0.08–0.09	180	15.253	6537	553.9	1361	229.630	
0.07–0.08	192	14.382	6973	522.3	1553	244.011	
0.06–0.07	304	19.753	11040	717.3	1857	263.764	
0.05–0.06	387	21.054	14054	764.6	2244	284.818	1(
0.04–0.05	477	21.231	17323	771.0	2721	306.049	1i
0.03–0.04	845	29.251	30687	1062.3	3566	335.300	12
0.02–0.03	1253	30.887	45504	1121.7	4819	366.187	13
0.01–0.02	3146	45.308	114251	1645.4	7965	411.496	14
0.005–0.01	3545	24.427	128742	887.1	11510	435.922	15
< 0.005	5437	13.444	197452	488.3	16947	449.367	16
Totals ->	16947	449.367	615454	16319.4			

Categories:	Min Avg. Gray	Max Avg. Gray	Min Meas. Area	Max Meas. Area	Count	Area (sq.mm)	Calculated Count (in 1 sq.meter)	Calculated PPM	Average Grayscale	Darkest Grayscale	Aver Size (sq.m
Total >=0.04 sq.mm.	0	255	0.040	99999	2721	306.049	98817	11114.6	62.13	16.00	0.1
Very Dark >= 0.04	0	60	0.040	99999	1232	167.061	44742	6067.1	52.94	16.00	0.1
Medium Dark	60	90	0.040	99999	1579	148.242	57344	5383.6	69.18	20.00	0.0
Light	90	255	0.040	99999							
Total 0.02–0.04	0	255	0.020	0.040	2098	60.138	76192	2184.0	69.25	27.00	0.0
Very Dark	0	60	0.020	0.040	335	10.278	12166	373.3	57.32	27.00	0.0
Medium Dark	60	90	0.020	0.040	1841	52.172	66859	1894.7	71.03	32.00	0.0
Light	90	255	0.020	0.040							
Total <0.04	0	255	0.000	0.040	14226	143.317	516637	5204.8	78.26	27.00	0.0

Sample Grayscale Brightness Analysis:

	99% Min	Mode	99% Max
Dirt Content:	23	90	90
Fiber Content:	104	184	211
Overall	72	184	214

Overall Grayscale Brightness = 176.2 = 69.1%
Overall Grayscale Std Deviation = 23.9 = 9.4%
Std.Dev. of Sheet Overall Ave. = 2.6 = 1.0%

Dirt Count Summary:

	All Sizes	>=0.040
Number of Specks:	16947	2721
Total Area (sq.mm):	449.37	306.05
Parts Per Million:	16319.4	11114.6
StdDev of Sheet PPM:	559.43	529.88
Count in 1 sq.m:	615454	98817
Counting Precision:	0.77	1.92

Western Michigan University

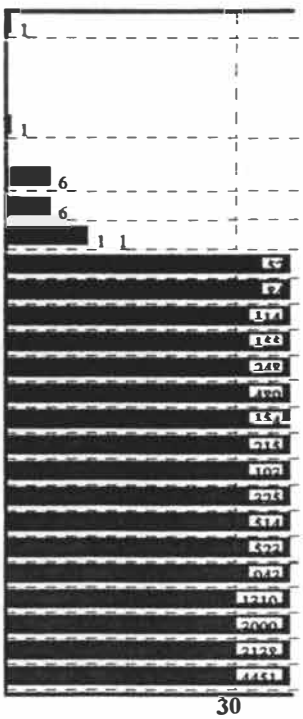
Spec*Scan 2000 - V.1.2.18

Fri 1-Nov-1996 18:53

Scanner Settings: Liquid Agglomeration, Tim Boven
Grade Identification: 1 #/ton BRD2342
Load / Reel Number: 30 #/ton Hexadecane

Resolution: 600 dots/inc
Threshold: 90 manual
White Level: 91
Black Level: 4
256-shade Grayscale mo

2 sheets 6-inch round
Total Area Scanned: 0.027536 sq.m.



Dirt Content Histogram	Dirt Spot Size	— Sample — Count	Area (sq.mm)	— Sample — Count (in 1 sq.meter)	PPM	Cumulative Count	Area (sq.mm)	Cu
	>= 5.000	1	5.181	36	188.2	1	5.181	
	4.00–5.00	0						
	3.00–4.00	0						
	2.50–3.00	0						
	2.00–2. 50	1	2.439	36	88.6	2	7.620	
	1.50–2.00	0						
	1.00–1.50	6	7.100	218	257.9	8	14.720	
	0.80–1.00	6	5.437	218	197.5	14	20.158	
	0.60–0.80	11	7.677	399	278.8	25	27.835	1(
	0.40–0.60	52	24.640	1888	894.8	77	52.475	1!
	0.30–0.40	84	29.315	3051	1064.6	161	81.790	2!
	0.25–0.30	114	31.011	4140	1126.2	275	112.801	40
	0.20–0.25	155	34.498	5629	1252.9	430	147.300	53
	0.15–0.20	248	43.156	9006	1567.3	678	190.456	69
	0.10–0.15	489	58.889	17759	2138.6	1167	249.345	90
	0.09–0.10	154	14.629	5593	531.3	1321	263.974	95
	0.08–0.09	215	18.315	7808	665.2	1536	282.289	102
	0.07–0.08	193	14.498	7009	526.5	1729	296.787	107
	0.06–0.07	325	21.294	11803	773.3	2054	318.081	115
	0.05–0.06	514	27.953	18667	1015.2	2568	346.035	1256
	0.04–0.05	523	23.251	18993	844.4	3091	369.286	1341
	0.03–0.04	943	32.579	34246	1183.1	4034	401.865	1459
	0.02–0.03	1310	32.455	47574	1178.7	5344	434.320	1577
	0.01–0.02	3009	43.586	109276	1582.9	8353	477.906	1735
	0.005–0.01	3138	21.855	113961	793.7	11491	499.761	1814
	< 0.005	4451	11.229	161644	407.8	15942	510.990	1855
	Totals ->	15942	510.990	578956	18557.3			

Categories:	Min Avg. Gray	Max Avg. Gray	Min Meas. Area	Max Meas. Area	Count	Area (sq.mm)	— Calculated — Count (in 1 sq.meter)	PPM	Average Grayscale	Darkest Grayscale	Average Size (sq.mm)
Total >=0.04 sq.mm.	0	255	0.040	99999	3091	369.286	112254	13411.1	61.12	14.00	0.119
Very Dark >= 0.04	0	60	0.040	99999	1609	242.214	58433	8796.3	53.33	14.00	0.151
Medium Dark	60	90	0.040	99999	1598	138.823	58034	5041.5	68.88	20.00	0.087
Light	90	255	0.040	99999							
Total 0.02–0.04	0	255	0.020	0.040	2253	65.034	81821	2361.8	68.04	29.00	0.029
Very Dark	0	60	0.020	0.040	436	13.652	15834	495.8	57.51	29.00	0.031
Medium Dark	60	90	0.020	0.040	1924	54.617	69873	1983.5	69.98	32.00	0.028
Light	90	255	0.020	0.040							
Total <0.04	0	255	0.000	0.040	12851	141.705	466702	5146.2	77.50	29.00	0.011

Sample Grayscale Brightness Analysis:

	99% Min	Mode	99% Max
Dirt Content:	23	90	90
Fiber Content:	106	195	217
Overall	65	195	219

Overall Grayscale Brightness = 183.6 = 72.0%
Overall Grayscale Std Deviation = 26.0 = 10.2%
Std.Dev. of Sheet Overall Ave. = 1.9 = 0.7%

Dirt Count Summary:

	All Sizes	>=0.040
Number of Specks:	15942	3091
Total Area (sq.mm):	510.99	369.29
Parts Per Million:	18557.3	13411.1
StdDev of Sheet PPM:	136.22	343.41
Count in 1 sq.m:	578956	112254
Counting Precision:	0.79	1.80

Western Michigan University

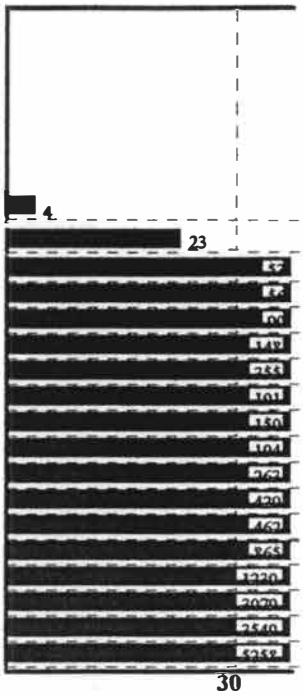
Spec*Scan 2000 - V.1.2.18

Fri 8-Nov-1996 16:18

Scanner Settings: Liquid Agglomeration, Tim Boven
Grade Identification: BRD 2340 5#/surfactant
Load / Reel Number: 30 #/ton Hexadecane

Resolution: 600 dots/inch
Threshold: 90 manual
White Level: 91
Black Level: 4
256-shade Grayscale mode

2 sheets 6-inch round
Total Area Scanned: 0.027536 sq.m.



Dirt Content Histogram	Dirt Spot Size	Sample Count	Sample Area (sq.mm)	Sample Count (in 1 sq.meter)	Sample PPM	Cumulative Count	Cumulative Area (sq.mm)	Cumulative Cum. PPM
	>= 5.000	0						
	4.00–5.00	0						
	3.00–4.00	0						
	2.50–3.00	0						
	2.00–2.50	0						
	1.50–2.00	0						
	1.00–1.50	0						
	0.80–1.00	0						
4	0.60–0.80	4	2.860	145	103.9	4	2.860	103.9
23	0.40–0.60	23	10.806	835	392.5	27	13.667	496.3
[illegible]	0.30–0.40	53	18.543	1925	673.4	80	32.210	1169.7
[illegible]	0.25–0.30	56	15.255	2034	554.0	136	47.464	1723.7
[illegible]	0.20–0.25	90	20.081	3268	729.3	226	67.545	2453.0
[illegible]	0.15–0.20	148	25.090	5375	911.2	374	92.635	3364.2
[illegible]	0.10–0.15	355	43.256	12892	1570.9	729	135.891	4935.1
[illegible]	0.09–0.10	101	9.588	3668	348.2	830	145.479	5283.3
[illegible]	0.08–0.09	150	12.740	5447	462.7	980	158.219	5745.9
[illegible]	0.07–0.08	194	14.570	7045	529.1	1174	172.789	6275.1
[illegible]	0.06–0.07	263	17.057	9551	619.5	1437	189.846	6894.5
[illegible]	0.05–0.06	429	23.154	15580	840.9	1866	213.000	7735.4
[illegible]	0.04–0.05	462	20.593	16778	747.9	2328	233.594	8483.3
[illegible]	0.03–0.04	865	29.842	31414	1083.8	3193	263.436	9567.1
[illegible]	0.02–0.03	1230	30.398	44669	1103.9	4423	293.834	10671.0
[illegible]	0.01–0.02	3079	44.656	111818	1621.7	7502	338.490	12292.7
[illegible]	0.005–0.01	3549	24.692	128887	896.7	11051	363.182	13189.5
[illegible]	< 0.005	5258	13.050	190952	473.9	16309	376.232	13663.4
	Totals ->	16309	376.232	592284	13663.4			

Categories:	Min Avg. Gray	Max Avg. Gray	Min Meas. Area	Max Meas. Area	Count	Area (sq.mm)	Calculated Count (in 1 sq.meter)	Calculated PPM	Average Grayscale	Darkest Grayscale	Average Size (sq.mm)
Total >=0.04 sq.mm.	0	255	0.040	99999	2328	233.594	84545	8483.3	62.98	14.00	0.100
Very Dark >= 0.04	0	60	0.040	99999	974	119.805	35372	4350.9	53.35	14.00	0.123
Medium Dark	60	90	0.040	99999	1428	121.296	51860	4405.0	69.39	20.00	0.085
Light	90	255	0.040	99999							
Total 0.02–0.04	0	255	0.020	0.040	2095	60.240	76083	2187.7	68.82	26.00	0.029
Very Dark	0	60	0.020	0.040	354	10.928	12856	396.9	57.27	26.00	0.031
Medium Dark	60	90	0.020	0.040	1819	51.547	66060	1872.0	70.69	30.00	0.028
Light	90	255	0.020	0.040							
Total <0.04	0	255	0.000	0.040	13981	142.638	507740	5180.1	78.15	26.00	0.010

Sample Grayscale Brightness Analysis:

	99% Min	Mode	99% Max
Dirt Content:	23	90	90
Fiber Content:	106	184	214
Overall	78	184	216

Overall Grayscale Brightness = 177.3 = 69.5%
Overall Grayscale Std Deviation = 23.2 = 9.1%
Std.Dev. of Sheet Overall Ave. = 4.7 = 1.8%

Dirt Count Summary:

	All Sizes	>=0.040
Number of Specks:	16309	2328
Total Area (sq.mm):	376.23	233.59
Parts Per Million:	13663.4	8483.3
StdDev of Sheet PPM:	762.75	551.05
Count in 1 sq.m:	592284	84545
Counting Precision:	0.78	2.07

Western Michigan University

Spec*Scan 2000 - V.1.2.18

Fri 1-Nov-1996 18:38

Scanner Settings: Liquid Agglomeration, Tim Boven
Grade Identification: 3 #/ton BRD2340
Load / Reel Number: 30 #/ton Hexadecane

Resolution: 600 dots/inch
Threshold: 90 manual
White Level: 91
Black Level: 4
256-shade Grayscale mode

2 sheets 6-inch round
Total Area Scanned: 0.027536 sq.m.

Dirt Content Histogram	Dirt Spot Size	Sample Count	Sample Area (sq.mm)	Sample Count (in 1 sq.meter)	Sample PPM	Cumulative Count	Cumulative Area (sq.mm)	Cumulative Cum. PPM
	>= 5.000	0						
	4.00–5.00	0						
	3.00–4.00	0						
	2.50–3.00	0						
1	2.00–2.50	1	2.090	36	75.9	1	2.090	75.9
1	1.50–2.00	1	1.563	36	56.8	2	3.652	132.6
2	1.00–1.50	2	2.271	73	82.5	4	5.923	215.1
1	0.80–1.00	1	0.910	36	33.1	5	6.833	248.2
11	0.60–0.80	11	7.477	399	271.5	16	14.310	519.7
66	0.40–0.60	52	24.319	1888	883.2	68	38.629	1402.9
92	0.30–0.40	92	31.199	3341	1133.0	160	69.828	2535.9
102	0.25–0.30	102	27.755	3704	1007.9	262	97.583	3543.9
155	0.20–0.25	155	34.624	5629	1257.4	417	132.206	4801.3
273	0.15–0.20	273	46.968	9914	1705.7	690	179.174	6507.0
604	0.10–0.15	604	72.914	21935	2648.0	1294	252.088	9154.9
170	0.09–0.10	170	16.183	6174	587.7	1464	268.271	9742.6
253	0.08–0.09	253	21.590	9188	784.1	1717	289.861	10526.7
248	0.07–0.08	248	18.652	9006	677.4	1965	308.513	11204.1
361	0.06–0.07	361	23.471	13110	852.4	2326	331.984	12056.5
550	0.05–0.06	550	29.919	19974	1086.6	2876	361.904	13143.1
569	0.04–0.05	569	25.457	20664	924.5	3445	387.361	14067.6
1003	0.03–0.04	1003	34.717	36425	1260.8	4448	422.078	15328.4
1316	0.02–0.03	1316	32.357	47792	1175.1	5764	454.435	16503.4
3320	0.01–0.02	3320	47.993	120570	1742.9	9084	502.428	18246.4
3690	0.005–0.01	3690	25.669	134008	932.2	12774	528.096	19178.6
5743	< 0.005	5743	14.238	208565	517.1	18517	542.335	19695.7
30	Totals ->	18517	542.335	672471	19695.7			

Categories:	Min Avg. Gray	Max Avg. Gray	Min Meas. Area	Max Meas. Area	Count	Area (sq.mm)	Calculated Count (in 1 sq.meter)	Calculated PPM	Average Grayscale	Darkest Grayscale	Average Size (sq.mm)
Total >=0.04 sq.mm.	0	255	0.040	99999	3445	387.361	125110	14067.6	61.88	14.00	0.112
Very Dark >= 0.04	0	60	0.040	99999	1621	221.303	58869	8036.9	53.57	14.00	0.137
Medium Dark	60	90	0.040	99999	1980	182.891	71906	6641.9	68.54	21.00	0.092
Light	90	255	0.040	99999							
Total 0.02–0.04	0	255	0.020	0.040	2319	67.074	84218	2435.9	68.81	24.00	0.029
Very Dark	0	60	0.020	0.040	359	11.231	13038	407.9	57.24	24.00	0.031
Medium Dark	60	90	0.020	0.040	2042	58.330	74158	2118.3	70.49	32.00	0.029
Light	90	255	0.020	0.040							
Total <0.04	0	255	0.000	0.040	15072	154.973	547361	5628.1	78.21	24.00	0.010

Sample Grayscale Brightness Analysis:

	99% Min	Mode	99% Max
Dirt Content:	23	90	90
Fiber Content:	104	189	211
Overall	65	189	213

Overall Grayscale Brightness = 175.3 = 68.8%
Overall Grayscale Std Deviation = 25.2 = 9.9%
Std.Dev. of Sheet Overall Ave. = 2.9 = 1.2%

Dirt Count Summary:

	All Sizes	>=0.040
Number of Specks:	18517	3445
Total Area (sq.mm):	542.33	387.36
Parts Per Million:	19695.7	14067.6
StdDev of Sheet PPM:	172.30	184.73
Count in 1 sq.m:	672471	125110
Counting Precision:	0.73	1.70

Western Michigan University

Spec*Scan 2000 - V.1.2.18

Fri 8-Nov-1996 11:41

Scanner Settings: Liquid Agglomeration, Tim Boven
Grade Identification: BRD2340 1#/ton
Load / Reel Number: 30 #/ton hexadecane

Resolution: 600 dots/inch
Threshold: 90 manual
White Level: 91
Black Level: 4
256-shade Grayscale mode

2 sheets 6-inch round
Total Area Scanned: 0.027536 sq.m.

Dirt Content Histogram	Dirt Spot Size	— Sample — Count	Area (sq.mm)	— Sample — Count (in 1 sq.meter)	PPM	— Cumulative — Count	Area (sq.mm)	Cum. PPM
	>= 5.000	0						
	4.00–5.00	0						
	3.00–4.00	0						
	2.50–3.00	0						
1	2.00–2.50	1	2.287	36	83.0	1	2.287	83.0
	1.50–2.00	0						
3	1.00–1.50	3	3.676	109	133.5	4	5.962	216.5
1	0.80–1.00	1	0.839	36	30.5	5	6.801	247.0
2	0.60–0.80	2	1.211	73	44.0	7	8.013	291.0
24	0.40–0.60	24	11.606	872	421.5	31	19.618	712.5
74	0.30–0.40	67	22.663	2433	823.0	98	42.281	1535.5
81	0.25–0.30	81	22.104	2942	802.7	179	64.385	2338.2
127	0.20–0.25	127	28.272	4612	1026.8	306	92.658	3365.0
214	0.15–0.20	214	36.649	7772	1331.0	520	129.307	4696.0
446	0.10–0.15	446	54.120	16197	1965.5	966	183.427	6661.4
123	0.09–0.10	123	11.697	4467	424.8	1089	195.124	7086.2
215	0.08–0.09	215	18.323	7808	665.4	1304	213.447	7751.6
183	0.07–0.08	183	13.742	6646	499.1	1487	227.189	8250.7
321	0.06–0.07	321	20.849	11658	757.2	1808	248.038	9007.9
445	0.05–0.06	445	24.149	16161	877.0	2253	272.187	9884.9
503	0.04–0.05	503	22.330	18267	810.9	2756	294.517	10695.8
931	0.03–0.04	931	32.104	33811	1165.9	3687	326.621	11861.7
1296	0.02–0.03	1296	31.955	47066	1160.5	4983	358.576	13022.2
3406	0.01–0.02	3406	49.077	123694	1782.3	8389	407.653	14804.5
4078	0.005–0.01	4078	28.277	148098	1026.9	12467	435.930	15831.4
6288	< 0.005	6288	15.577	228358	565.7	18755	451.507	16397.1
30	Totals ->	18755	451.507	681114	16397.1			

Categories:	Min Avg. Gray	Max Avg. Gray	Min Meas. Area	Max Meas. Area	Count	Area (sq.mm)	— Calculated — Count (in 1 sq.meter)	PPM	Average Grayscale	Darkest Grayscale	Average Size (sq.mm)
Total >=0.04 sq.mm.	0	255	0.040	99999	2756	294.517	100088	10695.8	62.42	15.00	0.107
Very Dark >= 0.04	0	60	0.040	99999	1231	158.479	44706	5755.4	53.36	15.00	0.129
Medium Dark	60	90	0.040	99999	1624	147.215	58978	5346.3	69.14	19.00	0.091
Light	90	255	0.040	99999							
Total 0.02–0.04	0	255	0.020	0.040	2227	64.059	80877	2326.4	68.52	26.00	0.029
Very Dark	0	60	0.020	0.040	423	12.961	15362	470.7	57.03	26.00	0.031
Medium Dark	60	90	0.020	0.040	1882	53.439	68347	1940.7	70.75	32.00	0.028
Light	90	255	0.020	0.040							
Total <0.04	0	255	0.000	0.040	15999	156.990	581026	5701.3	77.81	26.00	0.010

Sample Grayscale Brightness Analysis:

	99% Min	Mode	99% Max
Dirt Content:	23	90	90
Fiber Content:	104	189	210
Overall	71	189	212

Overall Grayscale Brightness = 177.0 = 69.4%
Overall Grayscale Std Deviation = 23.7 = 9.3%
Std.Dev. of Sheet Overall Ave. = 3.3 = 1.3%

Dirt Count Summary:

	All Sizes	>=0.040
Number of Specks:	18755	2756
Total Area (sq.mm):	451.51	294.52
Parts Per Million:	16397.1	10695.8
StdDev of Sheet PPM:	1206.48	807.39
Count in 1 sq.m:	681114	100088
Counting Precision:	0.73	1.90

Western Michigan University

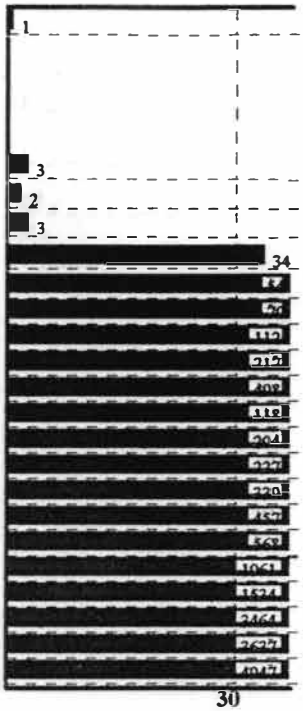
Spec*Scan 2000 - V.1.2.18

Fri 8-Nov-1996 16:04

Scanner Settings: Liquid Agglomeration, Tim Boven
Grade Identification: Control
Load / Reel Number: 30 #/ton Hexadecane

Resolution: 600 dots/inch
Threshold: 90 manual
White Level: 91
Black Level: 4
256-shade Grayscale mode

2 sheets 6-inch round
Total Area Scanned: 0.027536 sq.m.



Dirt Spot Size	Sample Count	Sample Area (sq.mm)	Sample Count (in 1 sq.meter)	Sample PPM	Cumulative Count	Cumulative Area (sq.mm)	Cumulative Cum. PPM
>= 5.000	1	5.260	36	191.0	1	5.260	191.0
4.00–5.00	0						
3.00–4.00	0						
2.50–3.00	0						
2.00–2.50	0						
1.50–2.00	0						
1.00–1.50	3	3.344	109	121.4	4	8.604	312.5
0.80–1.00	2	1.729	73	62.8	6	10.333	375.3
0.60–0.80	3	1.961	109	71.2	9	12.294	446.5
0.40–0.60	34	15.866	1235	576.2	43	28.160	1022.7
0.30–0.40	54	18.224	1961	661.8	97	46.384	1684.5
0.25–0.30	70	19.285	2542	700.4	167	65.669	2384.8
0.20–0.25	112	24.876	4067	903.4	279	90.545	3288.3
0.15–0.20	217	37.208	7881	1351.3	496	127.753	4639.5
0.10–0.15	498	60.579	18086	2200.0	994	188.332	6839.5
0.09–0.10	118	11.161	4285	405.3	1112	199.493	7244.9
0.08–0.09	204	17.263	7409	626.9	1316	216.757	7871.8
0.07–0.08	227	17.072	8244	620.0	1543	233.828	8491.8
0.06–0.07	339	22.111	12311	803.0	1882	255.940	9294.8
0.05–0.06	457	24.830	16597	901.7	2339	280.769	10196.5
0.04–0.05	568	25.376	20628	921.6	2907	306.146	11118.1
0.03–0.04	1061	36.728	38532	1333.8	3968	342.873	12451.9
0.02–0.03	1534	37.867	55709	1375.2	5502	380.741	13827.1
0.01–0.02	3464	50.095	125800	1819.3	8966	430.836	15646.4
0.005–0.01	3637	25.337	132083	920.2	12603	456.173	16566.6
< 0.005	4947	12.332	179657	447.8	17550	468.505	17014.4
Totals ->	17550	468.505	637353	17014.4			

Categories:	Min Avg. Gray	Max Avg. Gray	Min Meas. Area	Max Meas. Area	Count	Area (sq.mm)	Calculated Count (in 1 sq.meter)	Calculated PPM	Average Grayscale	Darkest Grayscale	Average Size (sq.mm)
Total >=0.04 sq.mm.	0	255	0.040	99999	2907	306.146	105572	11118.1	61.15	15.00	0.105
Very Dark >= 0.04	0	60	0.040	99999	1470	184.470	53385	6699.3	53.77	15.00	0.125
Medium Dark	60	90	0.040	99999	1562	133.326	56726	4841.9	68.00	22.00	0.085
Light	90	255	0.040	99999							
Total 0.02–0.04	0	255	0.020	0.040	2595	74.595	94241	2709.0	67.63	29.00	0.029
Very Dark	0	60	0.020	0.040	477	14.841	17323	539.0	57.59	29.00	0.031
Medium Dark	60	90	0.020	0.040	2230	63.120	80986	2292.3	69.39	32.00	0.028
Light	90	255	0.020	0.040							
Total <0.04	0	255	0.000	0.040	14643	162.359	531781	5896.3	76.92	29.00	0.011

Sample Grayscale Brightness Analysis:

	99% Min	Mode	99% Max
Dirt Content:	23	90	90
Fiber Content:	107	191	215
Overall	69	191	216

Overall Grayscale Brightness = 181.4 = 71.1%
Overall Grayscale Std Deviation = 24.5 = 9.6%
Std.Dev. of Sheet Overall Ave. = 0.3 = 0.1%

Dirt Count Summary:

	All Sizes	>=0.040
Number of Specks:	17550	2907
Total Area (sq.mm):	468.50	306.15
Parts Per Million:	17014.4	11118.1
StdDev of Sheet PPM:	300.15	177.00
Count in 1 sq.m:	637353	105572
Counting Precision:	0.75	1.85

Western Michigan University

Spec*Scan 2000 - V.1.2.18

Fri 1-Nov-1996 17:10

Scanner Settings:	Liquid Agglomeration, Tim Boven
Grade Identification:	5 #/ton Busperse 59
Load / Reel Number:	20 #/ton Hexadecane

Resolution: 600 dots/inch
Threshold: 90 manual
White Level: 91
Black Level: 4
256-shade Grayscale mode

2 sheets 6-inch round
Total Area Scanned: 0.027536 sq.m.

Dirt Content Histogram	Dirt Spot Size	Sample Count	Sample Area (sq.mm)	Sample Count (in 1 sq.meter)	Sample PPM	Cumulative Count	Cumulative Area (sq.mm)	Cumulative Cum. PPM
1	>= 5.000	1	6.543	36	237.6	1	6.543	237.6
	4.00–5.00	0						
	3.00–4.00	0						
1	2.50–3.00	1	2.704	36	98.2	2	9.247	335.8
	2.00–2.50	0						
1	1.50–2.00	1	1.683	36	61.1	3	10.930	396.9
	1.00–1.50	0						
5	0.80–1.00	5	4.321	182	156.9	8	15.251	553.9
4	0.60–0.80	4	2.710	145	98.4	12	17.961	652.3
36	0.40–0.60	36	16.658	1307	604.9	48	34.618	1257.2
74	0.30–0.40	74	25.043	2687	909.5	122	59.661	2166.7
84	0.25–0.30	84	22.893	3051	831.4	206	82.554	2998.1
130	0.20–0.25	130	28.955	4721	1051.6	336	111.509	4049.6
249	0.15–0.20	249	43.151	9043	1567.1	585	154.660	5616.7
482	0.10–0.15	482	58.348	17505	2119.0	1067	213.008	7735.7
144	0.09–0.10	144	13.667	5230	496.3	1211	226.674	8232.0
189	0.08–0.09	189	15.998	6864	581.0	1400	242.673	8813.0
230	0.07–0.08	230	17.323	8353	629.1	1630	259.995	9442.1
323	0.06–0.07	323	21.106	11730	766.5	1953	281.101	10208.6
492	0.05–0.06	492	26.792	17868	973.0	2445	307.893	11181.6
542	0.04–0.05	542	24.099	19683	875.2	2987	331.992	12056.7
1080	0.03–0.04	1080	37.452	39222	1360.1	4067	369.443	13416.9
1588	0.02–0.03	1588	39.353	57670	1429.2	5655	408.796	14846.0
3927	0.01–0.02	3927	56.522	142615	2052.7	9582	465.318	16898.7
4461	0.005–0.01	4461	30.898	162008	1122.1	14043	496.217	18020.8
6541	< 0.005	6541	16.394	237546	595.4	20584	512.611	18616.2
30	Totals ->	20584	512.611	747537	18616.2			

Categories:	Min Avg. Gray	Max Avg. Gray	Min Meas. Area	Max Meas. Area	Count	Area (sq.mm)	Calculated Count (in 1 sq.meter)	Calculated PPM	Average Grayscale	Darkest Grayscale	Average Size (sq.mm)
Total >=0.04 sq.mm.	0	255	0.040	99999	2987	331.992	108477	12056.7	63.50	16.00	0.111
Very Dark >= 0.04	0	60	0.040	99999	1182	169.183	42926	6144.1	53.98	16.00	0.143
Medium Dark	60	90	0.040	99999	1926	175.117	69945	6359.6	69.12	20.00	0.091
Light	90	255	0.040	99999							
Total 0.02–0.04	0	255	0.020	0.040	2668	76.805	96892	2789.3	68.74	26.00	0.029
Very Dark	0	60	0.020	0.040	400	12.314	14527	447.2	57.48	26.00	0.031
Medium Dark	60	90	0.020	0.040	2352	66.995	85416	2433.0	70.34	30.00	0.028
Light	90	255	0.020	0.040							
Total <0.04	0	255	0.000	0.040	17597	180.619	639060	6559.4	77.86	26.00	0.010

Sample Grayscale Brightness Analysis:

	99% Min	Mode	99% Max
Dirt Content:	24	90	90
Fiber Content:	103	190	216
Overall	69	190	218

Overall Grayscale Brightness = 176.6 = 69.2%
Overall Grayscale Std Deviation = 25.6 = 10.1%
Std.Dev. of Sheet Overall Ave. = 5.8 = 2.3%

Dirt Count Summary:

	All Sizes	>=0.040
Number of Specks:	20584	2987
Total Area (sq.mm):	512.61	331.99
Parts Per Million:	18616.2	12056.7
StdDev of Sheet PPM:	2053.82	700.71
Count in 1 sq.m:	747537	108477
Counting Precision:	0.70	1.83

Western Michigan University

Spec*Scan 2000 - V.1.2.18

Fri 8-Nov-1996 15:50

Scanner Settings: Liquid Agglomeration, Tim Boven
Grade Identification: Busperse 59 3#/ton
Load / Reel Number: 20 #/ton Hexadecane

Resolution: 600 dots/inch
Threshold: 90 manual
White Level: 91
Black Level: 4
256-shade Grayscale mode

2 sheets 6-inch round
Total Area Scanned: 0.027536 sq.m.

Dirt Content Histogram	Dirt Spot Size	Sample Count	Sample Area (sq.mm)	Sample Count (in 1 sq.meter)	Sample PPM	Cumulative Count	Cumulative Area (sq.mm)	Cumulative Cum. PPM
	>= 5.000	0						
	4.00–5.00	0						
	3.00–4.00	0						
	2.50–3.00	0						
	2.00–2.50	0						
	1.50–2.00	0						
	1.00–1.50	0						
2	0.80–1.00	2	1.771	73	64.3	2	1.771	64.3
6	0.60–0.80	6	3.858	218	140.1	8	5.629	204.4
	0.40–0.60	37	17.737	1344	644.1	45	23.366	848.6
	0.30–0.40	68	23.027	2470	836.3	113	46.393	1684.8
	0.25–0.30	74	20.097	2687	729.8	187	66.489	2414.7
	0.20–0.25	146	32.391	5302	1176.3	333	98.880	3591.0
	0.15–0.20	183	31.591	6646	1147.3	516	130.472	4738.3
	0.10–0.15	446	54.301	16197	1972.0	962	184.773	6710.3
	0.09–0.10	137	12.991	4975	471.8	1099	197.764	7182.1
	0.08–0.09	183	15.514	6646	563.4	1282	213.278	7745.5
	0.07–0.08	200	15.002	7263	544.8	1482	228.280	8290.3
	0.06–0.07	310	20.181	11258	732.9	1792	248.461	9023.2
	0.05–0.06	445	24.233	16161	880.1	2237	272.694	9903.3
	0.04–0.05	542	24.115	19683	875.8	2779	296.809	10779.0
	0.03–0.04	1058	36.283	38423	1317.7	3837	333.092	12096.7
	0.02–0.03	1459	35.937	52986	1305.1	5296	369.029	13401.8
	0.01–0.02	4074	58.373	147953	2119.9	9370	427.403	15521.7
	0.005–0.01	4691	32.395	170360	1176.5	14061	459.797	16698.2
	< 0.005	7052	17.579	256103	638.4	21113	477.376	17336.6
30	Totals ->	21113	477.376	766748	17336.6			

Categories:	Min Avg. Gray	Max Avg. Gray	Min Meas. Area	Max Meas. Area	Count	Area (sq.mm)	Calculated Count (in 1 sq.meter)	Calculated PPM	Average Grayscale	Darkest Grayscale	Average Size (sq.mm)
Total >=0.04 sq.mm.	0	255	0.040	99999	2779	296.809	100923	10779.0	63.38	16.00	0.107
Very Dark >= 0.04	0	60	0.040	99999	1072	141.525	38931	5139.7	53.35	16.00	0.132
Medium Dark	60	90	0.040	99999	1799	163.622	65333	5942.2	69.19	20.00	0.091
Light	90	255	0.040	99999							
Total 0.02–0.04	0	255	0.020	0.040	2517	72.221	91408	2622.8	68.88	29.00	0.029
Very Dark	0	60	0.020	0.040	355	10.894	12892	395.6	57.34	29.00	0.031
Medium Dark	60	90	0.020	0.040	2241	63.626	81385	2310.7	70.40	30.00	0.028
Light	90	255	0.020	0.040							
Total <0.04	0	255	0.000	0.040	18334	180.567	665825	6557.5	77.82	29.00	0.010

Sample Grayscale Brightness Analysis:

	99% Min	Mode	99% Max
Dirt Content:	23	90	90
Fiber Content:	103	190	214
Overall	72	190	217

Overall Grayscale Brightness = 178.0 = 69.8%
Overall Grayscale Std Deviation = 25.0 = 9.8%
Std.Dev. of Sheet Overall Ave. = 1.2 = 0.5%

Dirt Count Summary:

	All Sizes	>=0.040
Number of Specks:	21113	2779
Total Area (sq.mm):	477.38	296.81
Parts Per Million:	17336.6	10779.0
StdDev of Sheet PPM:	1305.61	19.97
Count in 1 sq.m:	766748	100923
Counting Precision:	0.69	1.90

Western Michigan University

Spec*Scan 2000 - V.1.2.18

Fri 1-Nov-1996 16:32

Scanner Settings: Liquid Agglomeration, Tim Boven
Grade Identification: 1 #/ton Busperse 59
Load / Reel Number: 20 #/ton Hexadecane

Resolution: 600 dots/inch
Threshold: 90 manual
White Level: 91
Black Level: 4
256-shade Grayscale mode

2 sheets 6-inch round
Total Area Scanned: 0.027536 sq.m.

Dirt Content Histogram	Dirt Spot Size	Sample Count	Sample Area (sq.mm)	Sample Count (in 1 sq.meter)	Sample PPM	Cumulative Count	Cumulative Area (sq.mm)	Cumulative Cum. PPM
	>= 5.000	0						
	4.00–5.00	0						
	3.00–4.00	0						
	2.50–3.00	0						
	2.00–2.50	0						
	1.50–2.00	0						
	1.00–1.50	0						
1	0.80–1.00	1	0.817	36	29.7	1	0.817	29.7
8	0.60–0.80	8	5.400	291	196.1	9	6.217	225.8
38	0.40–0.60	38	17.599	1380	639.1	47	23.815	864.9
66	0.30–0.40	66	22.690	2397	824.0	113	46.505	1688.9
64	0.25–0.30	64	17.378	2324	631.1	177	63.884	2320.0
113	0.20–0.25	113	25.002	4104	908.0	290	88.885	3228.0
217	0.15–0.20	217	37.339	7881	1356.0	507	126.224	4584.0
424	0.10–0.15	424	51.294	15398	1862.8	931	177.518	6446.8
115	0.09–0.10	115	10.916	4176	396.4	1046	188.434	6843.2
180	0.08–0.09	180	15.253	6537	553.9	1226	203.687	7397.2
187	0.07–0.08	187	14.045	6791	510.1	1413	217.732	7907.2
288	0.06–0.07	288	18.740	10459	680.6	1701	236.472	8587.8
423	0.05–0.06	423	22.995	15362	835.1	2124	259.466	9422.9
486	0.04–0.05	486	21.699	17650	788.0	2610	281.165	10210.9
928	0.03–0.04	928	32.070	33702	1164.7	3538	313.235	11375.6
1338	0.02–0.03	1338	32.934	48591	1196.0	4876	346.169	12571.6
3618	0.01–0.02	3618	51.941	131393	1886.3	8494	398.110	14457.9
4331	0.005–0.01	4331	29.866	157286	1084.6	12825	427.977	15542.6
6461	< 0.005	6461	16.378	234640	594.8	19286	444.355	16137.4
30	Totals ->	19286	444.355	700398	16137.4			

Categories:	Min Avg. Gray	Max Avg. Gray	Min Meas. Area	Max Meas. Area	Count	Area (sq.mm)	Calculated Count (in 1 sq.meter)	Calculated PPM	Average Grayscale	Darkest Grayscale	Average Size (sq.mm)
Total >=0.04 sq.mm.	0	255	0.040	99999	2610	281.165	94786	10210.9	64.17	16.00	0.108
Very Dark >= 0.04	0	60	0.040	99999	940	131.192	34137	4764.4	53.51	16.00	0.140
Medium Dark	60	90	0.040	99999	1767	160.206	64171	5818.1	69.62	19.00	0.091
Light	90	255	0.040	99999							
Total 0.02–0.04	0	255	0.020	0.040	2266	65.004	82293	2360.7	69.31	30.00	0.029
Very Dark	0	60	0.020	0.040	311	9.416	11294	341.9	57.67	30.00	0.030
Medium Dark	60	90	0.020	0.040	2028	57.774	73650	2098.2	70.76	32.00	0.028
Light	90	255	0.020	0.040							
Total <0.04	0	255	0.000	0.040	16676	163.188	605612	5926.4	78.21	30.00	0.010

Sample Grayscale Brightness Analysis:

	99% Min	Mode	99% Max
Dirt Content:	23	90	90
Fiber Content:	103	190	211
Overall	74	190	214

Overall Grayscale Brightness = 177.5 = 69.6%
Overall Grayscale Std Deviation = 24.1 = 9.4%
Std.Dev. of Sheet Overall Ave. = 1.3 = 0.5%

Dirt Count Summary:

	All Sizes	>=0.040
Number of Specks:	19286	2610
Total Area (sq.mm):	444.35	281.17
Parts Per Million:	16137.4	10210.9
StdDev of Sheet PPM:	2756.56	2583.80
Count in 1 sq.m:	700398	94786
Counting Precision:	0.72	1.96

Western Michigan University

Spec*Scan 2000 - V.1.2.18

Fri 1-Nov-1996 16:55

Scanner Settings: Liquid Agglomeration, Tim Boven
Grade Identification: 5 #/ton Busperse 47
Load / Reel Number: 20 #/ton Hexadecane

Resolution: 600 dots/inch
Threshold: 90 manual
White Level: 91
Black Level: 4
256-shade Grayscale mode

2 sheets 6-inch round
Total Area Scanned: 0.027536 sq.m.

Dirt Content Histogram	Dirt Spot Size	Sample Count	Sample Area (sq.mm)	Sample Count (in 1 sq.meter)	Sample PPM	Cumulative Count	Cumulative Area (sq.mm)	Cumulative Cum. PPM
	>= 5.000	0						
1	4.00--5.00	1	4.477	36	162.6	1	4.477	162.6
	3.00--4.00	0						
	2.50--3.00	0						
	2.00--2.50	0						
	1.50--2.00	0						
	1.00--1.50	0						
1	0.80--1.00	1	0.826	36	30.0	2	5.303	192.6
3	0.60--0.80	3	2.125	109	77.2	5	7.428	269.8
27	0.40--0.60	27	12.358	981	448.8	32	19.787	718.6
68	0.30--0.40	68	23.088	2470	838.5	100	42.875	1557.1
66	0.25--0.30	66	18.274	2397	663.7	166	61.149	2220.7
103	0.20--0.25	103	22.817	3741	828.6	269	83.966	3049.3
205	0.15--0.20	205	35.387	7445	1285.1	474	119.353	4334.5
398	0.10--0.15	398	48.505	14454	1761.5	872	167.859	6096.0
128	0.09--0.10	128	12.145	4649	441.1	1000	180.004	6537.1
149	0.08--0.09	149	12.703	5411	461.3	1149	192.706	6998.4
189	0.07--0.08	189	14.168	6864	514.5	1338	206.875	7513.0
296	0.06--0.07	296	19.219	10750	698.0	1634	226.094	8210.9
364	0.05--0.06	364	19.769	13219	717.9	1998	245.862	8928.8
474	0.04--0.05	474	21.066	17214	765.1	2472	266.929	9693.9
966	0.03--0.04	966	33.355	35082	1211.3	3438	300.284	10905.2
1363	0.02--0.03	1363	33.690	49499	1223.5	4801	333.974	12128.7
3886	0.01--0.02	3886	55.778	141126	2025.7	8687	389.752	14154.4
4702	0.005--0.01	4702	32.662	170760	1186.2	13389	422.414	15340.6
7250	< 0.005	7250	18.186	263294	660.5	20639	440.600	16001.0
30								
	Totals ->	20639	440.600	749534	16001.0			

Categories:	Min Avg. Gray	Max Avg. Gray	Min Meas. Area	Max Meas. Area	Count	Area (sq.mm)	Calculated Count (in 1 sq.meter)	Calculated PPM	Average Grayscale	Darkest Grayscale	Average Size (sq.mm)
Total >=0.04 sq.mm.	0	255	0.040	99999	2472	266.929	89774	9693.9	63.97	15.00	0.108
Very Dark >= 0.04	0	60	0.040	99999	887	123.959	32213	4501.7	53.37	15.00	0.140
Medium Dark	60	90	0.040	99999	1660	151.654	60285	5507.5	69.45	20.00	0.091
Light	90	255	0.040	99999							
Total 0.02--0.04	0	255	0.020	0.040	2329	67.045	84581	2434.8	69.17	27.00	0.029
Very Dark	0	60	0.020	0.040	358	11.027	13001	400.5	57.35	27.00	0.031
Medium Dark	60	90	0.020	0.040	2051	58.411	74485	2121.3	70.88	31.00	0.028
Light	90	255	0.020	0.040							
Total <0.04	0	255	0.000	0.040	18167	173.671	659760	6307.1	78.28	27.00	0.010

Sample Grayscale Brightness Analysis:

	99% Min	Mode	99% Max
Dirt Content:	23	90	90
Fiber Content:	103	182	215
Overall	74	182	218

Overall Grayscale Brightness = 175.7 = 68.9%
Overall Grayscale Std Deviation = 24.5 = 9.6%
Std.Dev. of Sheet Overall Ave. = 1.0 = 0.4%

Dirt Count Summary:

	All Sizes	>=0.040
Number of Specks:	20639	2472
Total Area (sq.mm):	440.60	266.93
Parts Per Million:	16001.0	9693.9
StdDev of Sheet PPM:	1675.34	950.97
Count in 1 sq.m:	749534	89774
Counting Precision:	0.70	2.01

Western Michigan University

Spec*Scan 2000 - V.1.2.18

Fri 1-Nov-1996 17:26

Scanner Settings: Liquid Agglomeration, Tim Boven
Grade Identification: 3 #/ton Busperse 47
Load / Reel Number: 20 #/ton Hexadecane

Resolution: 600 dots/inch
Threshold: 90 manual
White Level: 91
Black Level: 4
256-shade Grayscale mode

2 sheets 6-inch round
Total Area Scanned: 0.027536 sq.m.

Dirt Content Histogram	Dirt Spot Size	Sample Count	Sample Area (sq.mm)	Sample Count (in 1 sq.meter)	Sample PPM	Cumulative Count	Cumulative Area (sq.mm)	Cumulative Cum. PPM
	>= 5.000	0						
	4.00–5.00	0						
	3.00–4.00	0						
	2.50–3.00	0						
	2.00–2.50	0						
	1.50–2.00	0						
1	1.00–1.50	1	1.188	36	43.2	1	1.188	43.2
	0.80–1.00	0						
6	0.60–0.80	6	4.097	218	148.8	7	5.285	191.9
24	0.40–0.60	24	11.314	872	410.9	31	16.599	602.8
56	0.30–0.40	56	19.113	2034	694.1	87	35.712	1296.9
77	0.25–0.30	77	20.943	2796	760.6	164	56.654	2057.5
140	0.20–0.25	140	31.138	5084	1130.8	304	87.792	3188.3
177	0.15–0.20	177	30.443	6428	1105.6	481	118.235	4293.9
422	0.10–0.15	422	51.188	15326	1859.0	903	169.423	6152.8
126	0.09–0.10	126	12.000	4576	435.8	1029	181.423	6588.6
174	0.08–0.09	174	14.774	6319	536.5	1203	196.197	7125.2
193	0.07–0.08	193	14.462	7009	525.2	1396	210.660	7650.4
319	0.06–0.07	319	20.891	11585	758.7	1715	231.551	8409.1
431	0.05–0.06	431	23.430	15652	850.9	2146	254.981	9260.0
592	0.04–0.05	592	26.391	21499	958.4	2738	281.371	10218.4
1019	0.03–0.04	1019	34.912	37006	1267.9	3757	316.284	11486.3
1606	0.02–0.03	1606	39.565	58324	1436.8	5363	355.848	12923.1
4215	0.01–0.02	4215	60.312	153074	2190.3	9578	416.161	15113.5
5037	0.005–0.01	5037	35.035	182926	1272.3	14615	451.195	16385.8
7567	< 0.005	7567	18.969	274806	688.9	22182	470.165	17074.7
30	Totals ->	22182	470.165	805571	17074.7			

Categories:	Min Avg. Gray	Max Avg. Gray	Min Meas. Area	Max Meas. Area	Count	Area (sq.mm)	Calculated Count (in 1 sq.meter)	Calculated PPM	Average Grayscale	Darkest Grayscale	Average Size (sq.mm)
Total >=0.04 sq.mm.	0	255	0.040	99999	2738	281.371	99434	10218.4	63.81	16.00	0.103
Very Dark >= 0.04	0	60	0.040	99999	1011	130.679	36716	4745.8	53.90	16.00	0.129
Medium Dark	60	90	0.040	99999	1834	162.407	66604	5898.0	69.04	19.00	0.089
Light	90	255	0.040	99999							
Total 0.02–0.04	0	255	0.020	0.040	2625	74.477	95331	2704.7	68.77	26.00	0.028
Very Dark	0	60	0.020	0.040	395	11.858	14345	430.7	57.59	26.00	0.030
Medium Dark	60	90	0.020	0.040	2320	65.231	84254	2369.0	70.34	31.00	0.028
Light	90	255	0.020	0.040							
Total <0.04	0	255	0.000	0.040	19444	188.792	706136	6856.3	77.97	26.00	0.010

Sample Grayscale Brightness Analysis:

	99% Min	Mode	99% Max
Dirt Content:	24	90	90
Fiber Content:	103	189	212
Overall	72	189	214

Overall Grayscale Brightness = 176.0 = 69.0%
Overall Grayscale Std Deviation = 24.5 = 9.6%
Std.Dev. of Sheet Overall Ave. = 4.1 = 1.6%

Dirt Count Summary:

	All Sizes	>=0.040
Number of Specks:	22182	2738
Total Area (sq.mm):	470.16	281.37
Parts Per Million:	17074.7	10218.4
StdDev of Sheet PPM:	2516.88	1501.85
Count in 1 sq.m:	805571	99434
Counting Precision:	0.67	1.91

Western Michigan University

Spec*Scan 2000 - V.1.2.18

Fri 8-Nov-1996 12:03

Scanner Settings: Liquid Agglomeration, Tim Boven
Grade Identification: Busperse 47 1#/ton
Load / Reel Number: 20 #/ton hexadecane

Resolution: 600 dots/inch
Threshold: 90 manual
White Level: 91
Black Level: 4
256-shade Grayscale mode

2 sheets 6-inch round
Total Area Scanned: 0.027536 sq.m.

Dirt Content Histogram	Dirt Spot Size	Sample Count	Sample Area (sq.mm)	Sample Count (in 1 sq.meter)	Sample PPM	Cumulative Count	Cumulative Area (sq.mm)	Cumulative Cum. PPM
	>= 5.000	0						
	4.00–5.00	0						
	3.00–4.00	0						
	2.50–3.00	0						
1	2.00–2.50	1	2.116	36	76.9	1	2.116	76.9
1	1.50–2.00	1	1.505	36	54.7	2	3.622	131.5
1	1.00–1.50	1	1.005	36	36.5	3	4.627	168.0
5	0.80–1.00	5	4.371	182	158.7	8	8.998	326.8
11	0.60–0.80	11	7.462	399	271.0	19	16.461	597.8
	0.40–0.60	45	21.961	1634	797.5	64	38.421	1395.3
	0.30–0.40	95	32.683	3450	1186.9	159	71.104	2582.2
	0.25–0.30	76	20.894	2760	758.8	235	91.998	3341.1
	0.20–0.25	142	31.496	5157	1143.8	377	123.495	4484.9
	0.15–0.20	286	49.500	10386	1797.7	663	172.995	6282.6
	0.10–0.15	478	58.233	17359	2114.8	1141	231.228	8397.4
	0.09–0.10	173	16.367	6283	594.4	1314	247.595	8991.8
	0.08–0.09	218	18.400	7917	668.2	1532	265.995	9660.0
	0.07–0.08	229	17.194	8316	624.4	1761	283.189	10284.4
	0.06–0.07	428	27.910	15543	1013.6	2189	311.099	11298.0
	0.05–0.06	532	28.807	19320	1046.1	2721	339.906	12344.2
	0.04–0.05	657	29.149	23860	1058.6	3378	369.054	13402.7
	0.03–0.04	1204	41.540	43725	1508.6	4582	410.594	14911.3
	0.02–0.03	1660	41.160	60285	1494.8	6242	451.754	16406.1
	0.01–0.02	4498	64.793	163351	2353.0	10740	516.546	18759.1
	0.005–0.01	5025	34.669	182490	1259.1	15765	551.215	20018.2
	< 0.005	7714	19.281	280145	700.2	23479	570.496	20718.4
30	Totals ->	23479	570.496	852673	20718.4			

Categories:	Min Avg. Gray	Max Avg. Gray	Min Meas. Area	Max Meas. Area	Count	Area (sq.mm)	Calculated Count (in 1 sq.meter)	Calculated PPM	Average Grayscale	Darkest Grayscale	Average Size (sq.mm)
Total >=0.04 sq.mm.	0	255	0.040	99999	3378	369.054	122677	13402.7	62.83	14.00	0.109
Very Dark >= 0.04	0	60	0.040	99999	1411	191.267	51242	6946.1	53.36	14.00	0.136
Medium Dark	60	90	0.040	99999	2105	191.880	76446	6968.4	68.99	21.00	0.091
Light	90	255	0.040	99999							
Total 0.02–0.04	0	255	0.020	0.040	2864	82.699	104010	3003.3	68.22	26.00	0.029
Very Dark	0	60	0.020	0.040	488	14.885	17722	540.6	57.29	26.00	0.031
Medium Dark	60	90	0.020	0.040	2497	71.333	90682	2590.6	69.96	31.00	0.029
Light	90	255	0.020	0.040							
Total <0.04	0	255	0.000	0.040	20101	201.441	729996	7315.6	77.23	26.00	0.010

Sample Grayscale Brightness Analysis:

	99% Min	Mode	99% Max
Dirt Content:	22	90	90
Fiber Content:	102	190	213
Overall	65	190	215

Overall Grayscale Brightness = 176.9 = 69.4%
Overall Grayscale Std Deviation = 26.1 = 10.2%
Std.Dev. of Sheet Overall Ave. = 2.3 = 0.9%

Dirt Count Summary:

	All Sizes	>=0.040
Number of Specks:	23479	3378
Total Area (sq.mm):	570.50	369.05
Parts Per Million:	20718.4	13402.7
StdDev of Sheet PPM:	3180.41	2488.44
Count in 1 sq.m:	852673	122677
Counting Precision:	0.65	1.72

Western Michigan University

Spec*Scan 2000 - V.1.2.18

Fri 1-Nov-1996 17:36

Scanner Settings: Liquid Agglomeration, Tim Boven
Grade Identification: 5 #/ton BRD2340
Load / Reel Number: 20 #/ton Hexadecane

Resolution: 600 dots/inch
Threshold: 90 manual
White Level: 91
Black Level: 4
256-shade Grayscale mode

2 sheets 6-inch round
Total Area Scanned: 0.027536 sq.m.

Dirt Content Histogram	Dirt Spot Size	— Sample — Count	Area (sq.mm)	— Sample — Count (in 1 sq.meter)	PPM	— Cumulative — Count	Area (sq.mm)	Cum. PPM
	>= 5.000	0						
	4.00–5.00	0						
	3.00–4.00	0						
	2.50–3.00	0						
	2.00–2.50	0						
	1.50–2.00	0						
2	1.00–1.50	2	2.220	73	80.6	2	2.220	80.6
2	0.80–1.00	2	1.801	73	65.4	4	4.022	146.0
7	0.60–0.80	7	4.591	254	166.7	11	8.613	312.8
	0.40–0.60	41	19.487	1489	707.7	52	28.100	1020.5
	0.30–0.40	86	29.527	3123	1072.3	138	57.627	2092.8
	0.25–0.30	77	20.916	2796	759.6	215	78.543	2852.4
	0.20–0.25	123	27.276	4467	990.6	338	105.819	3843.0
	0.15–0.20	237	40.860	8607	1483.9	575	146.679	5326.9
	0.10–0.15	461	55.717	16742	2023.4	1036	202.396	7350.3
	0.09–0.10	142	13.487	5157	489.8	1178	215.884	7840.1
	0.08–0.09	205	17.414	7445	632.4	1383	233.298	8472.5
	0.07–0.08	191	14.303	6936	519.4	1574	247.601	8992.0
	0.06–0.07	338	22.041	12275	800.5	1912	269.642	9792.4
	0.05–0.06	464	25.341	16851	920.3	2376	294.983	10712.7
	0.04–0.05	540	24.142	19611	876.7	2916	319.124	11589.4
	0.03–0.04	1137	39.276	41292	1426.4	4053	358.400	13015.8
	0.02–0.03	1542	38.056	56000	1382.0	5595	396.456	14397.9
	0.01–0.02	4082	58.981	148244	2142.0	9677	455.437	16539.8
	0.005–0.01	4761	33.051	172902	1200.3	14438	488.488	17740.1
	< 0.005	7141	17.890	259335	649.7	21579	506.378	18389.8
30	Totals ->	21579	506.378	783672	18389.8			

Categories:	Min Avg. Gray	Max Avg. Gray	Min Meas. Area	Max Meas. Area	Count	Area (sq.mm)	— Calculated — Count (in 1 sq.meter)	PPM	Average Grayscale	Darkest Grayscale	Average Size (sq.mm)
Total >=0.04 sq.mm.	0	255	0.040	99999	2916	319.124	105899	11589.4	63.30	15.00	0.109
Very Dark >= 0.04	0	60	0.040	99999	1150	158.423	41764	5753.4	53.77	15.00	0.138
Medium Dark	60	90	0.040	99999	1894	173.613	68783	6305.0	68.87	21.00	0.092
Light	90	255	0.040	99999							
Total 0.02–0.04	0	255	0.020	0.040	2679	77.332	97292	2808.4	68.53	28.00	0.029
Very Dark	0	60	0.020	0.040	427	13.088	15507	475.3	57.42	28.00	0.031
Medium Dark	60	90	0.020	0.040	2342	66.885	85053	2429.0	70.22	31.00	0.029
Light	90	255	0.020	0.040							
Total <0.04	0	255	0.000	0.040	18663	187.253	677773	6800.4	77.92	28.00	0.010

Sample Grayscale Brightness Analysis:

	99% Min	Mode	99% Max
Dirt Content:	23	90	90
Fiber Content:	103	183	211
Overall	70	183	213

Overall Grayscale Brightness = 174.4 = 68.4%
Overall Grayscale Std Deviation = 24.6 = 9.7%
Std.Dev. of Sheet Overall Ave. = 3.6 = 1.4%

Dirt Count Summary:

	All Sizes	>=0.040
Number of Specks:	21579	2916
Total Area (sq.mm):	506.38	319.12
Parts Per Million:	18389.8	11589.4
StdDev of Sheet PPM:	2752.23	2137.49
Count in 1 sq.m:	783672	105899
Counting Precision:	0.68	1.85

Western Michigan University

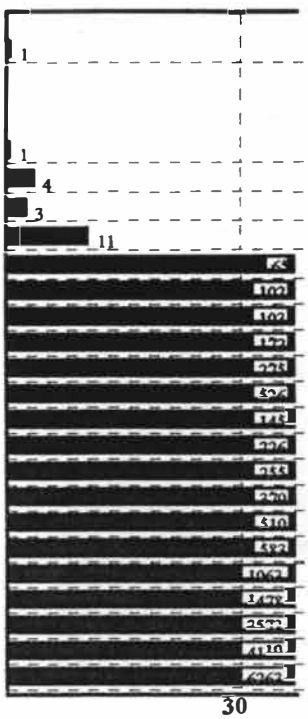
Spec*Scan 2000 - V.1.2.18

Fri 1-Nov-1996 17:51

Scanner Settings: Liquid Agglomeration, Tim Boven
Grade Identification: 3 #/ton BRD2340
Load / Reel Number: 20 #/ton Hexadecane

Resolution: 600 dots/inch
Threshold: 90 manual
White Level: 91
Black Level: 4
256-shade Grayscale mode

2 sheets 6-inch round
Total Area Scanned: 0.027536 sq.m.



Dirt Content Histogram

Dirt Spot Size	Sample Count	Sample Area (sq.mm)	Sample Count (in 1 sq.meter)	Sample PPM	Cumulative Count	Cumulative Area (sq.mm)	Cumulative Cum. PPM
>= 5.000	0						
4.00–5.00	1	4.138	36	150.3	1	4.138	150.3
3.00–4.00	0						
2.50–3.00	0						
2.00–2.50	0						
1.50–2.00	1	1.534	36	55.7	2	5.672	206.0
1.00–1.50	4	4.672	145	169.7	6	10.344	375.7
0.80–1.00	3	2.579	109	93.7	9	12.923	469.3
0.60–0.80	11	7.683	399	279.0	20	20.606	748.3
0.40–0.60	65	30.235	2361	1098.0	85	50.841	1846.3
0.30–0.40	102	34.943	3704	1269.0	187	85.783	3115.3
0.25–0.30	103	28.310	3741	1028.1	290	114.093	4143.5
0.20–0.25	172	38.097	6246	1383.5	462	152.190	5527.0
0.15–0.20	275	47.726	9987	1733.2	737	199.916	7260.2
0.10–0.15	526	63.792	19102	2316.7	1263	263.708	9576.9
0.09–0.10	145	13.769	5266	500.0	1408	277.477	10077.0
0.08–0.09	226	19.194	8208	697.0	1634	296.671	10774.0
0.07–0.08	255	19.091	9261	693.3	1889	315.762	11467.4
0.06–0.07	379	24.688	13764	896.6	2268	340.451	12363.9
0.05–0.06	510	27.704	18521	1006.1	2778	368.155	13370.1
0.04–0.05	583	25.918	21172	941.2	3361	394.072	14311.3
0.03–0.04	1063	36.694	38604	1332.6	4424	430.766	15643.9
0.02–0.03	1478	36.425	53676	1322.8	5902	467.191	16966.7
0.01–0.02	3573	51.450	129759	1868.5	9475	518.641	18835.2
0.005–0.01	4119	28.450	149587	1033.2	13594	547.091	19868.4
< 0.005	6263	15.667	227450	569.0	19857	562.758	20437.3
Totals ->	19857	562.758	721135	20437.3			

Categories:	Min Avg. Gray	Max Avg. Gray	Min Meas. Area	Max Meas. Area	Count	Area (sq.mm)	Calculated Count (in 1 sq.meter)	Calculated PPM	Average Grayscale	Darkest Grayscale	Average Size (sq.mm)
Total >=0.04 sq.mm.	0	255	0.040	99999	3361	394.072	122059	14311.3	62.92	15.00	0.117
Very Dark >= 0.04	0	60	0.040	99999	1389	215.694	50443	7833.2	53.81	15.00	0.155
Medium Dark	60	90	0.040	99999	2106	194.706	76482	7071.0	68.74	20.00	0.092
Light	90	255	0.040	99999							
Total 0.02–0.04	0	255	0.020	0.040	2541	73.118	92280	2655.4	69.60	28.00	0.029
Very Dark	0	60	0.020	0.040	286	8.939	10386	324.6	57.59	28.00	0.031
Medium Dark	60	90	0.020	0.040	2328	66.375	84545	2410.5	70.77	32.00	0.029
Light	90	255	0.020	0.040							
Total <0.04	0	255	0.000	0.040	16496	168.685	599075	6126.0	78.48	28.00	0.010

Sample Grayscale Brightness Analysis:

	99% Min	Mode	99% Max
Dirt Content:	22	90	90
Fiber Content:	102	180	214
Overall	65	180	216

Overall Grayscale Brightness = 173.9 = 68.2%
Overall Grayscale Std Deviation = 25.7 = 10.1%
Std.Dev. of Sheet Overall Ave. = 6.1 = 2.4%

Dirt Count Summary:

	All Sizes	>=0.040
Number of Specks:	19857	3361
Total Area (sq.mm):	562.76	394.07
Parts Per Million:	20437.3	14311.3
StdDev of Sheet PPM:	1960.87	989.08
Count in 1 sq.m:	721135	122059
Counting Precision:	0.71	1.72

Western Michigan University

Spec*Scan 2000 - V.1.2.18

Fri 1-Nov-1996 17:4

Scanner Settings: Liquid Agglomeration, Tim Boven
Grade Identification: 1 #/ton BRD2340
Load / Reel Number: 20 #/ton Hexadecane

Resolution: 600 dots/
Threshold: 90 manu
White Level: 91
Black Level: 4
256-shade Grayscale

2 sheets 6-inch round
Total Area Scanned: 0.027536 sq.m.

Dirt Content Histogram	Dirt Spot Size	Sample Count	Sample Area (sq.mm)	Sample Count (in 1 sq.meter)	Sample PPM	Cumulative Count	Cumulative Area (sq.mm)
1	>= 5.000	1	12.498	36	453.9	1	12.498
1	4.00–5.00	1	4.219	36	153.2	2	16.717
	3.00–4.00	0					
	2.50–3.00	0					
2	2.00–2.50	2	4.201	73	152.6	4	20.918
1	1.50–2.00	1	1.600	36	58.1	5	22.518
5	1.00–1.50	5	5.894	182	214.1	10	28.412
7	0.80–1.00	7	6.168	254	224.0	17	34.581
21	0.60–0.80	21	14.362	763	521.6	38	48.943
	0.40–0.60	69	32.631	2506	1185.0	107	81.574
	0.30–0.40	95	32.634	3450	1185.2	202	114.208
	0.25–0.30	93	25.398	3377	922.4	295	139.606
	0.20–0.25	140	31.034	5084	1127.0	435	170.640
	0.15–0.20	255	44.129	9261	1602.6	690	214.769
	0.10–0.15	538	65.041	19538	2362.1	1228	279.811
	0.09–0.10	158	15.020	5738	545.5	1386	294.830
	0.08–0.09	228	19.419	8280	705.2	1614	314.250
	0.07–0.08	222	16.711	8062	606.9	1836	330.961
	0.06–0.07	367	23.887	13328	867.5	2203	354.848
	0.05–0.06	476	25.817	17287	937.6	2679	380.666
	0.04–0.05	556	24.846	20192	902.3	3235	405.512
	0.03–0.04	1032	35.462	37479	1287.9	4267	440.974
	0.02–0.03	1329	32.634	48265	1185.2	5596	473.608
	0.01–0.02	3244	46.416	117810	1685.7	8840	520.024
	0.005–0.01	3793	26.171	137748	950.4	12633	546.195
	< 0.005	5879	14.735	213504	535.1	18512	560.930
30	Totals ->	18512	560.930	672289	20371.0		

Categories:	Min Avg. Gray	Max Avg. Gray	Min Meas. Area	Max Meas. Area	Count	Area (sq.mm)	Calculated Count (in 1 sq.meter)	Calculated PPM	Average Grayscale	Darkest Grayscale	Average Size (sq.mm)
Total >=0.04 sq.mm.	0	255	0.040	99999	3235	405.512	117484	14726.7	62.91	17.00	0.125
Very Dark >= 0.04	0	60	0.040	99999	1349	232.418	48991	8440.6	53.88	17.00	0.172
Medium Dark	60	90	0.040	99999	2038	189.859	74013	6895.0	68.68	20.00	0.093
Light	90	255	0.040	99999							
Total 0.02–0.04	0	255	0.020	0.040	2361	68.097	85743	2473.0	69.17	29.00	0.029
Very Dark	0	60	0.020	0.040	328	10.090	11912	366.4	57.55	29.00	0.031
Medium Dark	60	90	0.020	0.040	2102	60.054	76337	2180.9	70.68	31.00	0.029
Light	90	255	0.020	0.040							
Total <0.04	0	255	0.000	0.040	15277	155.418	554806	5644.2	78.26	29.00	0.010

Sample Grayscale Brightness Analysis:

	99% Min	Mode	99% Max
Dirt Content:	23	90	90
Fiber Content:	103	191	216
Overall	65	191	218

Overall Grayscale Brightness = 179.6 = 70.4%
Overall Grayscale Std Deviation = 26.6 = 10.4%
Std.Dev. of Sheet Overall Ave. = 4.3 = 1.7%

Dirt Count Summary:

	All Sizes	>=0.040
Number of Specks:	18512	3235
Total Area (sq.mm):	560.93	405.51
Parts Per Million:	20371.0	14726.7
StdDev of Sheet PPM:	1107.26	1301.01
Count in 1 sq.m:	672289	117484
Counting Precision:	0.73	1.76

Western Michigan University

Spec*Scan 2000 - V.1.2.18

Fri 1-Nov-1996 17:19

Scanner Settings: Liquid Agglomeration, Tim Boven
Grade Identification: 5 #/ton BRD2342
Load / Reel Number: 20 #/ton Hexadecane

Resolution: 600 dots/inch
Threshold: 90 manual
White Level: 91
Black Level: 4
256-shade Grayscale mode

2 sheets 6-inch round
Total Area Scanned: 0.027536 sq.m.

Dirt Content Histogram	Dirt Spot Size	Sample Count	Sample Area (sq.mm)	Sample Count (in 1 sq.meter)	Sample PPM	Cumulative Count	Cumulative Area (sq.mm)	Cumulative Cum. PPM
	>= 5.000	0						
	4.00–5.00	0						
	3.00–4.00	0						
	2.50–3.00	0						
	2.00–2.50	0						
2	1.50–2.00	2	3.367	73	122.3	2	3.367	122.3
	1.00–1.50	0						
1	0.80–1.00	1	0.842	36	30.6	3	4.210	152.9
12	0.60–0.80	12	8.109	436	294.5	15	12.319	447.4
60	0.40–0.60	60	28.534	2179	1036.3	75	40.853	1483.6
83	0.30–0.40	83	28.319	3014	1028.4	158	69.172	2512.1
86	0.25–0.30	86	23.527	3123	854.4	244	92.699	3366.5
152	0.20–0.25	152	34.025	5520	1235.7	396	126.724	4602.2
249	0.15–0.20	249	42.735	9043	1552.0	645	169.459	6154.1
541	0.10–0.15	541	65.346	19647	2373.1	1186	234.805	8527.3
152	0.09–0.10	152	14.437	5520	524.3	1338	249.242	9051.6
244	0.08–0.09	244	20.710	8861	752.1	1582	269.952	9803.7
232	0.07–0.08	232	17.416	8425	632.5	1814	287.368	10436.2
414	0.06–0.07	414	26.975	15035	979.6	2228	314.343	11415.8
559	0.05–0.06	559	30.312	20301	1100.8	2787	344.655	12516.6
636	0.04–0.05	636	28.296	23097	1027.6	3423	372.951	13544.2
1132	0.03–0.04	1132	39.092	41110	1419.7	4555	412.042	14963.9
1560	0.02–0.03	1560	38.423	56654	1395.4	6115	450.465	16359.3
3929	0.01–0.02	3929	56.696	142687	2059.0	10044	507.161	18418.3
4407	0.005–0.01	4407	30.553	160046	1109.6	14451	537.713	19527.8
6718	< 0.005	6718	16.729	243974	607.5	21169	554.443	20135.4
30	Totals ->	21169	554.443	768782	20135.4			

Categories:	Min Avg. Gray	Max Avg. Gray	Min Meas. Area	Max Meas. Area	Count	Area (sq.mm)	Calculated Count (in 1 sq.meter)	Calculated PPM	Average Grayscale	Darkest Grayscale	Average Size (sq.mm)
Total >=0.04 sq.mm.	0	255	0.040	99999	3423	372.951	124311	13544.2	63.12	15.00	0.109
Very Dark >= 0.04	0	60	0.040	99999	1375	192.882	49935	7004.8	54.08	15.00	0.140
Medium Dark	60	90	0.040	99999	2204	193.741	80041	7036.0	68.55	21.00	0.088
Light	90	255	0.040	99999							
Total 0.02–0.04	0	255	0.020	0.040	2692	77.514	97764	2815.0	68.98	25.00	0.029
Very Dark	0	60	0.020	0.040	351	10.882	12747	395.2	57.52	25.00	0.031
Medium Dark	60	90	0.020	0.040	2419	69.054	87849	2507.8	70.35	32.00	0.029
Light	90	255	0.020	0.040							
Total <0.04	0	255	0.000	0.040	17746	181.491	644471	6591.1	77.97	25.00	0.010

Sample Grayscale Brightness Analysis:

	99% Min	Mode	99% Max
Dirt Content:	23	90	90
Fiber Content:	102	183	212
Overall	66	183	214

Overall Grayscale Brightness = 174.0 = 68.2%
Overall Grayscale Std Deviation = 25.3 = 9.9%
Std.Dev. of Sheet Overall Ave. = 5.6 = 2.2%

Dirt Count Summary:

	All Sizes	>=0.040
Number of Specks:	21169	3423
Total Area (sq.mm):	554.44	372.95
Parts Per Million:	20135.4	13544.2
StdDev of Sheet PPM:	3229.01	2733.09
Count in 1 sq.m:	768782	124311
Counting Precision:	0.69	1.71

Western Michigan University

Spec*Scan 2000 - V.1.2.18

Fri 8-Nov-1996 15:38

Scanner Settings: Liquid Agglomeration, Tim Boven
Grade Identification: BRD2342 3#/ton
Load / Reel Number: 20 #/ton Hexadecane

Resolution: 600 dots/inch
Threshold: 90 manual
White Level: 91
Black Level: 4
256-shade Grayscale mode

2 sheets 6-inch round
Total Area Scanned: 0.027536 sq.m.

Dirt Content Histogram	Dirt Spot Size	— Sample — Count	Area (sq.mm)	— Sample — Count (in 1 sq.meter)	PPM	——— Cumulative ——— Count	Area (sq.mm)	Cum. PPM
	>= 5.000	0						
	4.00–5.00	0						
	3.00–4.00	0						
	2.50–3.00	0						
	2.00–2.50	0						
	1.50–2.00	0						
	1.00–1.50	0						
	0.80–1.00	0						
6	0.60–0.80	6	4.065	218	147.6	6	4.065	147.6
28	0.40–0.60	28	13.699	1017	497.5	34	17.763	645.1
	0.30–0.40	75	25.509	2724	926.4	109	43.272	1571.5
	0.25–0.30	53	14.504	1925	526.7	162	57.776	2098.2
	0.20–0.25	100	22.324	3632	810.7	262	80.101	2909.0
	0.15–0.20	181	30.769	6573	1117.4	443	110.869	4026.4
	0.10–0.15	356	43.384	12929	1575.5	799	154.253	5601.9
	0.09–0.10	117	11.088	4249	402.7	916	165.341	6004.6
	0.08–0.09	153	12.932	5556	469.6	1069	178.273	6474.2
	0.07–0.08	159	11.977	5774	435.0	1228	190.249	6909.2
	0.06–0.07	271	17.722	9842	643.6	1499	207.972	7552.8
	0.05–0.06	319	17.362	11585	630.5	1818	225.334	8183.3
	0.04–0.05	394	17.586	14309	638.7	2212	242.920	8822.0
	0.03–0.04	785	27.011	28508	980.9	2997	269.931	9802.9
	0.02–0.03	1158	28.597	42054	1038.5	4155	298.527	10841.4
	0.01–0.02	3064	43.812	111273	1591.1	7219	342.340	12432.5
	0.005–0.01	3700	25.466	134371	924.8	10919	367.806	13357.4
	< 0.005	6171	15.342	224109	557.2	17090	383.148	13914.6
30	Totals ->	17090	383.148	620647	13914.6			

Categories:	Min Avg. Gray	Max Avg. Gray	Min Meas. Area	Max Meas. Area	Count	Area (sq.mm)	— Calculated — Count (in 1 sq.meter)	PPM	Average Grayscale	Darkest Grayscale	Average Size (sq.mm)
Total >=0.04 sq.mm.	0	255	0.040	99999	2212	242.920	80332	8822.0	64.53	16.00	0.110
Very Dark >= 0.04	0	60	0.040	99999	791	112.117	28726	4071.7	52.89	16.00	0.142
Medium Dark	60	90	0.040	99999	1512	140.007	54910	5084.6	70.35	22.00	0.093
Light	90	255	0.040	99999							
Total 0.02–0.04	0	255	0.020	0.040	1943	55.608	70563	2019.5	70.38	27.00	0.029
Very Dark	0	60	0.020	0.040	246	7.556	8934	274.4	57.28	27.00	0.031
Medium Dark	60	90	0.020	0.040	1757	49.828	63808	1809.6	71.86	33.00	0.028
Light	90	255	0.020	0.040							
Total <0.04	0	255	0.000	0.040	14878	140.228	540316	5092.6	79.20	27.00	0.009

Sample Grayscale Brightness Analysis:

	99% Min	Mode	99% Max
Dirt Content:	23	90	90
Fiber Content:	104	182	207
Overall	79	182	209

Overall Grayscale Brightness = 173.7 = 68.1%
Overall Grayscale Std Deviation = 22.4 = 8.8%
Std.Dev. of Sheet Overall Ave. = 3.8 = 1.5%

Dirt Count Summary:

	All Sizes	>=0.040
Number of Specks:	17090	2212
Total Area (sq.mm):	383.15	242.92
Parts Per Million:	13914.6	8822.0
StdDev of Sheet PPM:	709.46	620.64
Count in 1 sq.m:	620647	80332
Counting Precision:	0.76	2.13

Western Michigan University

Spec*Scan 2000 - V.1.2.18

Fri 1-Nov-1996 18:17

Scanner Settings: Liquid Agglomeration, Tim Boven
Grade Identification: 1 #/ton BRD2342
Load / Reel Number: 20 #/ton Hexadecane

Resolution: 600 dots/inch
Threshold: 90 manual
White Level: 91
Black Level: 4
256-shade Grayscale mode

2 sheets 6-inch round
Total Area Scanned: 0.027536 sq.m.

Dirt Content Histogram	Dirt Spot Size	Sample Count	Sample Area (sq.mm)	Sample Count (in 1 sq.meter)	Sample PPM	Cumulative Count	Cumulative Area (sq.mm)	Cumulative Cum. PPM
	>= 5.000	0						
1	4.00–5.00	1	4.953	36	179.9	1	4.953	179.9
	3.00–4.00	0						
	2.50–3.00	0						
1	2.00–2.50	1	2.016	36	73.2	2	6.970	253.1
1	1.50–2.00	1	1.670	36	60.7	3	8.640	313.8
7	1.00–1.50	7	8.470	254	307.6	10	17.109	621.4
6	0.80–1.00	6	5.353	218	194.4	16	22.462	815.8
37	0.60–0.80	37	25.043	1344	909.5	53	47.505	1725.2
103	0.40–0.60	103	49.303	3741	1790.5	156	96.808	3515.7
128	0.30–0.40	128	43.746	4649	1588.7	284	140.554	5104.4
119	0.25–0.30	119	32.575	4322	1183.0	403	173.129	6287.4
213	0.20–0.25	213	47.631	7735	1729.8	616	220.760	8017.2
324	0.15–0.20	324	55.821	11767	2027.2	940	276.581	10044.4
611	0.10–0.15	611	74.660	22189	2711.4	1551	351.241	12755.8
175	0.09–0.10	175	16.602	6355	602.9	1726	367.843	13358.7
258	0.08–0.09	258	21.896	9370	795.2	1984	389.739	14153.9
245	0.07–0.08	245	18.375	8898	667.3	2229	408.114	14821.2
357	0.06–0.07	357	23.319	12965	846.9	2586	431.433	15668.1
491	0.05–0.06	491	26.609	17831	966.4	3077	458.042	16634.4
587	0.04–0.05	587	26.066	21318	946.6	3664	484.108	17581.1
1019	0.03–0.04	1019	35.109	37006	1275.0	4683	519.218	18856.1
1369	0.02–0.03	1369	33.803	49717	1227.6	6052	553.021	20083.7
3301	0.01–0.02	3301	47.651	119880	1730.5	9353	600.672	21814.2
3734	0.005–0.01	3734	25.845	135605	938.6	13087	626.516	22752.8
5287	< 0.005	5287	13.235	192005	480.6	18374	639.751	23233.4
30	Totals ->	18374	639.751	667278	23233.4			

Categories:	Min Avg. Gray	Max Avg. Gray	Min Meas. Area	Max Meas. Area	Count	Area (sq.mm)	Calculated Count (in 1 sq.meter)	Calculated PPM	Average Grayscale	Darkest Grayscale	Average Size (sq.mm)
Total >=0.04 sq.mm.	0	255	0.040	99999	3664	484.108	133063	17581.1	63.27	14.00	0.132
Very Dark >= 0.04	0	60	0.040	99999	1505	267.436	54656	9712.3	53.61	14.00	0.178
Medium Dark	60	90	0.040	99999	2291	233.210	83201	8469.4	69.42	17.00	0.102
Light	90	255	0.040	99999							
Total 0.02–0.04	0	255	0.020	0.040	2388	68.912	86724	2502.6	70.43	28.00	0.029
Very Dark	0	60	0.020	0.040	240	7.615	8716	276.5	57.50	28.00	0.032
Medium Dark	60	90	0.020	0.040	2215	63.350	80441	2300.6	71.51	30.00	0.029
Light	90	255	0.020	0.040							
Total <0.04	0	255	0.000	0.040	14710	155.642	534214	5652.4	78.82	28.00	0.011

Sample Grayscale Brightness Analysis:

	99% Min	Mode	99% Max
Dirt Content:	22	89	90
Fiber Content:	102	190	216
Overall	61	190	218

Overall Grayscale Brightness = 173.5 = 68.0%
Overall Grayscale Std Deviation = 27.7 = 10.9%
Std.Dev. of Sheet Overall Ave. = 9.9 = 3.9%

Dirt Count Summary:

	All Sizes	>=0.040
Number of Specks:	18374	3664
Total Area (sq.mm):	639.75	484.11
Parts Per Million:	23233.4	17581.1
StdDev of Sheet PPM:	3975.10	3296.57
Count in 1 sq.m:	667278	133063
Counting Precision:	0.74	1.65

Western Michigan University

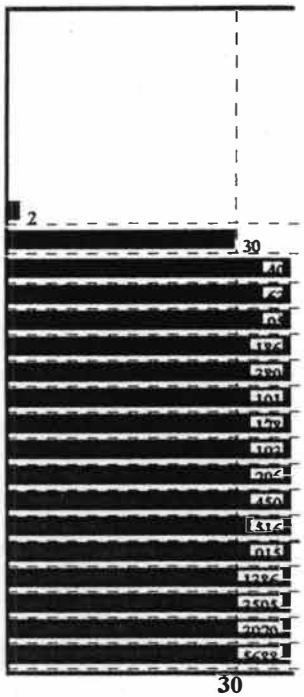
Spec*Scan 2000 - V.1.2.18

Fri 8-Nov-1996 15:57

Scanner Settings: Liquid Agglomeration, Tim Boven
Grade Identification: Control
Load / Reel Number: 20 #/ton Hexadecane

Resolution: 600 dots/inch
Threshold: 90 manual
White Level: 91
Black Level: 4
256-shade Grayscale mode

2 sheets 6-inch round
Total Area Scanned: 0.027536 sq.m.



Dirt Content Histogram

Dirt Spot Size	Sample Count	Sample Area (sq.mm)	Sample Count (in 1 sq.meter)	Sample PPM	Cumulative Count	Cumulative Area (sq.mm)	Cumulative Cum. PPM
>= 5.000	0						
4.00–5.00	0						
3.00–4.00	0						
2.50–3.00	0						
2.00–2.50	0						
1.50–2.00	0						
1.00–1.50	0						
0.80–1.00	0						
0.60–0.80	2	1.375	73	49.9	2	1.375	49.9
0.40–0.60	30	13.955	1089	506.8	32	15.330	556.7
0.30–0.40	40	13.568	1453	492.7	72	28.898	1049.5
0.25–0.30	63	17.179	2288	623.9	135	46.077	1673.4
0.20–0.25	95	21.100	3450	766.3	230	67.178	2439.6
0.15–0.20	186	31.824	6755	1155.7	416	99.002	3595.4
0.10–0.15	380	46.185	13800	1677.3	796	145.187	5272.7
0.09–0.10	101	9.572	3668	347.6	897	154.758	5620.3
0.08–0.09	178	15.129	6464	549.4	1075	169.887	6169.7
0.07–0.08	193	14.550	7009	528.4	1268	184.438	6698.1
0.06–0.07	296	19.362	10750	703.2	1564	203.800	7401.3
0.05–0.06	450	24.369	16342	885.0	2014	228.169	8286.3
0.04–0.05	516	22.970	18739	834.2	2530	251.138	9120.4
0.03–0.04	915	31.663	33230	1149.9	3445	282.802	10270.3
0.02–0.03	1386	34.290	50335	1245.3	4831	317.092	11515.6
0.01–0.02	3595	51.817	130557	1881.8	8426	368.909	13397.5
0.005–0.01	3970	27.556	144176	1000.7	12396	396.466	14398.2
< 0.005	5688	14.272	206568	518.3	18084	410.738	14916.5
Totals ->	18084	410.738	656746	14916.5			

Categories:	Min Avg. Gray	Max Avg. Gray	Min Meas. Area	Max Meas. Area	Count	Area (sq.mm)	Calculated Count (in 1 sq.meter)	Calculated PPM	Average Grayscale	Darkest Grayscale	Average Size (sq.mm)
Total >=0.04 sq.mm.	0	255	0.040	99999	2530	251.138	91881	9120.4	62.09	16.00	0.099
Very Dark >= 0.04	0	60	0.040	99999	1157	135.719	42018	4928.8	53.88	16.00	0.117
Medium Dark	60	90	0.040	99999	1485	124.905	53930	4536.1	68.33	22.00	0.084
Light	90	255	0.040	99999							
Total 0.02–0.04	0	255	0.020	0.040	2301	65.954	83564	2395.2	67.93	26.00	0.029
Very Dark	0	60	0.020	0.040	401	12.341	14563	448.2	57.62	26.00	0.031
Medium Dark	60	90	0.020	0.040	1997	56.441	72524	2049.7	69.62	33.00	0.028
Light	90	255	0.020	0.040							
Total <0.04	0	255	0.000	0.040	15554	159.599	564865	5796.1	77.37	26.00	0.010

Sample Grayscale Brightness Analysis:

	99% Min	Mode	99% Max
Dirt Content:	23	90	90
Fiber Content:	107	191	214
Overall	75	191	215

Overall Grayscale Brightness = 181.6 = 71.2%
Overall Grayscale Std Deviation = 23.7 = 9.3%
Std.Dev. of Sheet Overall Ave. = 1.0 = 0.4%

Dirt Count Summary:

	All Sizes	>=0.040
Number of Specks:	18084	2530
Total Area (sq.mm):	410.74	251.14
Parts Per Million:	14916.5	9120.4
StdDev of Sheet PPM:	353.90	476.87
Count in 1 sq.m:	656746	91881
Counting Precision:	0.74	1.99

Western Michigan University

Spec*Scan 2000 - V.1.2.18

Fri 8-Nov-1996 16:12

Scanner Settings: Liquid Agglomeration, Tim Boven
Grade Identification: Control 0 #/surfactant
Load / Reel Number: 0 #/ton Hexadecane

Resolution: 600 dots/inch
Threshold: 90 manual
White Level: 91
Black Level: 4
256-shade Grayscale mode

2 sheets 6-inch round
Total Area Scanned: 0.027536 sq.m.

Dirt Content Histogram	Dirt Spot Size	— Sample — Count	Area (sq.mm)	— Sample — Count (in 1 sq.meter)	PPM	— Cumulative — Count	Area (sq.mm)	Cum. PPM
	>= 5.000	0						
	4.00–5.00	0						
	3.00–4.00	0						
	2.50–3.00	0						
	2.00–2.50	0						
	1.50–2.00	0						
	1.00–1.50	0						
	0.80–1.00	0						
5	0.60–0.80	5	3.219	182	116.9	5	3.219	116.9
31	0.40–0.60	31	14.473	1126	525.6	36	17.692	642.5
43	0.30–0.40	43	14.694	1562	533.6	79	32.385	1176.1
76	0.25–0.30	76	21.043	2760	764.2	155	53.428	1940.3
102	0.20–0.25	102	22.780	3704	827.3	257	76.208	2767.6
219	0.15–0.20	219	37.502	7953	1361.9	476	113.710	4129.5
364	0.10–0.15	364	43.968	13219	1596.8	840	157.678	5726.3
92	0.09–0.10	92	8.679	3341	315.2	932	166.357	6041.5
166	0.08–0.09	166	14.059	6029	510.6	1098	180.416	6552.1
170	0.07–0.08	170	12.798	6174	464.8	1268	193.214	7016.8
285	0.06–0.07	285	18.568	10350	674.3	1553	211.782	7691.2
374	0.05–0.06	374	20.315	13582	737.8	1927	232.097	8428.9
430	0.04–0.05	430	19.197	15616	697.2	2357	251.294	9126.1
840	0.03–0.04	840	28.953	30506	1051.5	3197	280.248	10177.6
1227	0.02–0.03	1227	30.305	44560	1100.6	4424	310.553	11278.2
3683	0.01–0.02	3683	52.604	133753	1910.4	8107	363.157	13188.6
4621	0.005–0.01	4621	31.755	167818	1153.2	12728	394.912	14341.8
7477	< 0.005	7477	18.675	271538	678.2	20205	413.587	15020.0
30	Totals ->	20205	413.587	733773	15020.0			

Categories:	Min Avg. Gray	Max Avg. Gray	Min Meas. Area	Max Meas. Area	Count	Area (sq.mm)	— Calculated — Count (in 1 sq.meter)	PPM	Average Grayscale	Darkest Grayscale	Average Size (sq.mm)
Total >=0.04 sq.mm.	0	255	0.040	99999	2357	251.294	85598	9126.1	66.17	15.00	0.107
Very Dark >= 0.04	0	60	0.040	99999	677	91.233	24586	3313.3	53.48	15.00	0.135
Medium Dark	60	90	0.040	99999	1740	166.400	63191	6043.0	70.89	23.00	0.096
Light	90	255	0.040	99999							
Total 0.02–0.04	0	255	0.020	0.040	2067	59.258	75066	2152.0	71.12	28.00	0.029
Very Dark	0	60	0.020	0.040	208	6.371	7554	231.4	57.31	28.00	0.031
Medium Dark	60	90	0.020	0.040	1904	54.231	69146	1969.5	72.37	31.00	0.028
Light	90	255	0.020	0.040							
Total <0.04	0	255	0.000	0.040	17848	162.292	648175	5893.9	79.42	28.00	0.009

Sample Grayscale Brightness Analysis:

	99% Min	Mode	99% Max
Dirt Content:	25	90	90
Fiber Content:	103	180	204
Overall	77	180	206

Overall Grayscale Brightness = 171.2 = 67.1%
Overall Grayscale Std Deviation = 22.3 = 8.7%
Std.Dev. of Sheet Overall Ave. = 2.7 = 1.0%

Dirt Count Summary:

	All Sizes	>=0.040
Number of Specks:	20205	2357
Total Area (sq.mm):	413.59	251.29
Parts Per Million:	15020.0	9126.1
StdDev of Sheet PPM:	1029.12	221.08
Count in 1 sq.m:	733773	85598
Counting Precision:	0.70	2.06

Western Michigan University

Spec*Scan 2000 - V.1.2.18

Tue 12-Nov-1996 15:09

Scanner Settings: Liquid Agglomeration, Tim Boven
Grade Identification: Flotation Pad
Load / Reel Number: BRD2340 .33grams/cell

Resolution: 600 dots/inch
Threshold: 90 manual
White Level: 91
Black Level: 4
256-shade Grayscale mode

2 sheets 6-inch round
Total Area Scanned: 0.027536 sq.m.

Dirt Content Histogram	Dirt Spot Size	Sample Count	Sample Area (sq.mm)	Sample Count (in 1 sq.meter)	Sample PPM	Cumulative Count	Cumulative Area (sq.mm)	Cumulative Cum. PPM
	>= 5.000	0						
	4.00–5.00	0						
	3.00–4.00	0						
	2.50–3.00	0						
	2.00–2.50	0						
	1.50–2.00	0						
	1.00–1.50	0						
	0.80–1.00	0						
1	0.60–0.80	1	0.737	36	26.7	1	0.737	26.7
11	0.40–0.60	11	5.140	399	186.7	12	5.876	213.4
20	0.30–0.40	20	6.624	726	240.5	32	12.500	454.0
31	0.25–0.30	31	8.495	1126	308.5	63	20.995	762.5
55	0.20–0.25	55	12.228	1997	444.1	118	33.222	1206.5
115	0.15–0.20	115	19.815	4176	719.6	233	53.038	1926.1
280	0.10–0.15	280	33.658	10169	1222.3	513	86.696	3148.5
90	0.09–0.10	90	8.484	3268	308.1	603	95.179	3456.6
106	0.08–0.09	106	9.020	3850	327.6	709	104.199	3784.1
124	0.07–0.08	124	9.323	4503	338.6	833	113.522	4122.7
200	0.06–0.07	200	13.066	7263	474.5	1033	126.588	4597.2
301	0.05–0.06	301	16.299	10931	591.9	1334	142.887	5189.2
338	0.04–0.05	338	14.939	12275	542.5	1672	157.826	5731.7
639	0.03–0.04	639	21.982	23206	798.3	2311	179.809	6530.0
1017	0.02–0.03	1017	25.120	36934	912.3	3328	204.929	7442.3
2871	0.01–0.02	2871	40.480	104264	1470.1	6199	245.409	8912.4
4133	0.005–0.01	4133	28.467	150096	1033.8	10332	273.876	9946.2
7471	< 0.005	7471	18.457	271320	670.3	17803	292.332	10616.5
30	Totals ->	17803	292.332	646541	10616.5			

Categories:	Min Avg. Gray	Max Avg. Gray	Min Meas. Area	Max Meas. Area	Count	Area (sq.mm)	Calculated Count (in 1 sq.meter)	Calculated PPM	Average Grayscale	Darkest Grayscale	Average Size (sq.mm)
Total >=0.04 sq.mm.	0	255	0.040	99999	1672	157.826	60721	5731.7	65.20	19.00	0.094
Very Dark >= 0.04	0	60	0.040	99999	539	64.357	19575	2337.2	54.26	19.00	0.119
Medium Dark	60	90	0.040	99999	1192	99.574	43289	3616.2	69.89	23.00	0.084
Light	90	255	0.040	99999							
Total 0.02–0.04	0	255	0.020	0.040	1656	47.102	60140	1710.6	69.84	29.00	0.028
Very Dark	0	60	0.020	0.040	207	6.254	7517	227.1	57.13	29.00	0.030
Medium Dark	60	90	0.020	0.040	1490	42.038	54111	1526.7	71.34	33.00	0.028
Light	90	255	0.020	0.040							
Total <0.04	0	255	0.000	0.040	16131	134.506	585820	4884.8	78.32	29.00	0.008

Sample Grayscale Brightness Analysis:

	99% Min	Mode	99% Max
Dirt Content:	27	89	90
Fiber Content:	109	189	210
Overall	86	189	211

Overall Grayscale Brightness = 178.0 = 69.8%
Overall Grayscale Std Deviation = 21.1 = 8.3%
Std.Dev. of Sheet Overall Ave. = 2.9 = 1.2%

Dirt Count Summary:

	All Sizes	>=0.040
Number of Specks:	17803	1672
Total Area (sq.mm):	292.33	157.83
Parts Per Million:	10616.5	5731.7
StdDev of Sheet PPM:	1258.67	603.15
Count in 1 sq.m:	646541	60721
Counting Precision:	0.75	2.45

Appendix III

Standard Print

Paper Science and Process Engineering at Western Michigan University require a senior thesis project to be done. Paper Science and Process Engineering at Western Michigan University require a senior thesis project to be done.Paper Science and Process Engineering at Western Michigan University require a senior thesis project to be done. Paper Science and Process Engineering at Western Michigan University require a senior thesis project to be done.Paper Science and Process Engineering at Western Michigan University require a senior thesis project to be done. Paper Science and Process Engineering at Western Michigan University require a senior thesis project to be done.Paper Science and Process Engineering at Western Michigan University require a senior thesis project to be done. Paper Science and Process Engineering at Western Michigan University require a senior thesis project to be done. Paper Science and Process Engineering at Western Michigan University require a senior thesis project to be done.Paper Science and Process Engineering at Western Michigan University require a senior thesis project to be done. Paper Science and Process Engineering at Western Michigan University require a senior thesis project to be done.Paper Science and Process Engineering at Western Michigan University require a senior thesis project to be done. Paper Science and Process Engineering at Western Michigan University require a senior thesis project to be done. Paper Science and Process Engineering at Western Michigan University require a senior thesis project to be done.Paper Science and Process Engineering at Western Michigan University require a senior thesis project to be done. Paper Science and Process Engineering at Western Michigan University require a senior thesis project to be done.Paper Science and Process Engineering at Western Michigan University require a senior thesis project to be done. Paper Science and Process Engineering at Western Michigan University require a senior thesis project to be done. Paper Science and Process Engineering at Western Michigan University require a senior thesis project to be done.Paper Science and Process Engineering at Western Michigan University require a senior thesis project to be done. Paper Science and Process Engineering at Western