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Laboratory investigation of the effect of the dampening solution on the loss of surface strength of coated paper

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LABORATORY INVESTIGATION OF THE EFFECT OF THE DAMPENING SOLUTION ON THE LOSS OF SURFACE STRENGTH OF COATED PAPER

by

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Abstract

Wet pick is thought to be caused by the presence of water used in lithography. The quantity of the wetting fluid, surface tension of the wetting fluid and the time interval between wetting and printing were tested to see if they affect the paper surface strength. Two rolls of web paper are pre-sampled from the RIT press room. One was found to exhibit the problem of wet pick while the other did not exhibit this defect. These papers were tested on the IGT Printability Tester in a manner similar to that predicted on press when a moisture film of 0.2 micrometer is applied with no delay between application of ink and water. This method can be used to predict the defect referred to as wet pick. Adding to the moisture film thickness results in an increased wet pick in both good and bad paper with a delay between dampening and inking of 0.3 and 0.6 seconds. This researcher hypothesized that for a wetting fluid, the factors that contribute to picking are the quantity, the evaporation rate, and the wetting characteristic.

Chapter 1

Introduction

The purpose

The purpose of this study was to investigate the effect of the dampening solution on the loss of surface strength of coated paper. The desire was to quantify this loss of strength in the laboratory with the hope that this method may be used to predict the defect referred to as wet pick. Wet pick occurs in lithography and is presumed to be caused by the presence of dampening solution normally used in this process. This water solution is thought to weaken the paper surface.

Statement of the problem

Paper is often adversely affected in lithography due to the required use of dampening solution that is used to maintain the non-image area. This water solution is thought to cause a decrease in the surface strength for example of some paper

surfaces. When a coated paper is printed by the offset process, it is essential that the surface strength of the paper is sufficiently high, and/or unaffected by surface water, otherwise unacceptable defects in the print are to be anticipated.[1] In general, lithographers do not test their paper for pick resistance prior to printing. As a result, they start to print paper and frequently then find that it picks, splits, or blisters.[2] Under such conditions, there are two things the pressman can do: reduce the tack of the ink, or slow down the press. Because the above remedies are limited - and costly - the best solution is to eliminate unsatisfactory paper before it can get on the press. Paper, therefore, should be tested for pick resistance before going to press.[3]

Offset lithography is subject to a unique set of problems which relate to the action of the press fountain solution apart from its intended function of maintaining plate desensitization.[4] One such problem is wet pick. Wet pick is the lowering of surface strength due to the presence of water introduced by the printing process. Wet picking can result from the loss of surface strength due to dampening solution that weakens the surface prior to the moment of printing impression.[5] Surface strength of paper is qualitatively defined as that property of the sheet which

enables its surface to accept the transfer of ink without picking. The important variables that impact on surface strength of paper in the printing process are the following:[6]

1. Ink - tack, viscosity, composition.
2. Press speed and temperature.
3. Ambient temperature, relative humidity, and paper moisture content.
4. Ratio of image to nonimage area, both macro and micro.
5. Topography and surface chemistry of all the printing surfaces.
6. Specific properties of paper (e.g., interfiber bonding, wettability, roughness)
7. Levels of dampening and ink application: printing pressures; and type of press blankets.

Surface failure problems may result due to the use of water in the offset lithographic printing process. The water may weaken or readily penetrate the surface.[7] On multi-color presses, the distance between the two printing units and printing speed may also influence the occurrence of wet pick. Research questions this author wishes to consider are outlined by the following: Is paper surface strength affected by the quantity of fountain solution, surface tension of the fountain solution and/or the time interval between wetting and printing?

The industry uses the IGT Printability Tester to predict the quality of the paper surface. One of the common responses from this apparatus is surface strength. This method consists of printing a strip of paper at an accelerating velocity. The printing is done from the rim of a narrow cylindrical sector with a standardized ink film. The Westvaco disk is one device that may be used to apply a controlled ink film thickness for each test. As the printing speed rises, the forces exerted on the surface of the specimen increase until picking occurs. The result is commonly reported in terms of the viscosity of the ink and the printing speed (viscosity-velocity-product, or VVP) at the point of continuous picking and blistering. This author finds this method inappropriate for predicting wet strength because it does not take into account the effect of water on the paper surface.

The IGT Printability Tester AIC2-5 utilizes a new accessory that is a damping unit. This accessory allows the application of different film thickness of moisture to the paper surface prior to application of ink or oil of known viscosity. This author questions: Can offset press performance be predicted by tests on the IGT Printability Tester AIC2-5 for wet pick? The research conducted in this

paper attempts to use the IGT Printability Tester AIC2-5 to approach the questions proposed in this chapter.

Endnotes for Chapter 1

1. M. Righadl, J. Borg, A. Skeppstedt, G. Malhammar and G. Engstrom, "Surface Treatment of $CaCO_3$ with Polymers in Order to Improve the Surface Strength of Coated Papers," TAPPI Coating Conference, 1978.
2. Robert F. Reed and Gordon C. Wheeler, The LTF Pick Tester for Offset Papers, New York: Lithographic Technical Foundation, Inc., 1953, p. 7.
3. Michael Bruno, Working with Paper: a Guide for Printers, New York: NAPL, 1977, p. 18.
4. N. Beckman, "A Banch Test for Predicting Effect of the Fountain Solution on Pick and Curl of Offset Papers," TAGA Proceedings, 1959, p. 49.
5. William H. Bureau, What the Printer Should Know About Paper, Pittsburgh: GATF, 1982, P.94.
6. Surface Strength of Technology, Atlanta: TAPPI Inc., 1983, P. iii.
7. Ibid.

Chapter 2

Theoretical Basis

Lithographic principle in brief

In the lithographic printing process, the damping rollers attempt to apply a uniform layer of moisture to the plate surface as it rotates. The ink roller next contacts the plate. The film of water on the non-image area of the plate and the ink film on the inking roller have polar attraction. The film with the lowest cohesive strength is the one that splits, and that is water. Thus, the non-image area does not accept the transfer of ink.[1]

In printing, if the water used has a low surface tension, it is assumed that the press operator can use less water to dampen the plate. The paper should not be influenced by the water because less moisture is expected to transfer and be absorbed by the paper. In another case, if the surface tension of the water is high, a greater amount of water might be required to wet the plate surface. When a paper with high

water absorbency contacts the blanket, it will absorb more water and may be weakened. A weakened coating can be picked off causing print defects or blanket piling. Blanket piling can cause loss of resolution, lower solid ink density, decreased plate life and contamination of the inking system in severe cases. On the other hand, a paper that has low absorbency possibly will absorb less water and probably will not exhibit wet strength problems on press.

Viscosity velocity product

"Pick occurs when the forces involved in splitting an ink film exceed the surface strength of the paper".[2] In 1946, the Institute of Paper Chemistry established the fundamental rule for "picking". This states that "rupture velocity and the viscosity of ink -- viscosity velocity product (VVP) -- remains constant as long as printing pressure, ink film thickness and the quality of paper remain fixed".[3] To evaluate the surface strength of the paper, VVP has been used and various discussions have on the following fundamental relationship

$$T = K \eta V$$

in which K = constant

T = surface strength of the paper

η = viscosity of ink

V = rupture velocity

From a fundamental standpoint, research workers prefer to work with unpigmented oils because they are Newtonian.[4] A successful offset ink must be highly pigmented, resulting in a non-Newtonian fluid. The rheological properties of ink and oils depend upon the rate of shear. In cylindrical press systems, the shear rate in the nip is never constant. So it is impossible to estimate the viscosity at the moment of split.[5] IGT pick tests are carried out with oil. This fluid is Newtonian making it possible to know the viscosity, which is not possible with inks that are not Newtonian.

Charlesworth and Coupe conclude in their study that "whereas the viscosity-velocity product for a given paper was approximately constant for a series of mineral oils, there was no simple relationship between the viscosity and the critical velocity for the entire range of oils and inks tested".[6] The viscosity of the pick oil is the value of viscosity at the moment of printing, not the value measured in a viscometer (See Table 1).[7] There are three grades of viscosity available from IGT for the pick oil: low, medium and high.

Table 1. The Effective Viscosity of the Pick Test Oils

KIND	TEMPERATURE		
	20°C	23°C	25°C
LOW	22.5	17.5	14.5
MEDIUM	68	52	44
HIGH	145	110	92

Surface tension

Surface tension is the tendency of the surface of a liquid to contract to the smallest area possible due to the attraction between the individual particles of which the liquid is composed.[8] This may be illustrated by falling droplets of water. Dripping water is comprised of spherical globules. These are spherical due to cohesion of the water molecules drawing them together into the center of the liquid. If a droplet lands on a surface, such as glass, for which it has

some affinity the droplet becomes flatter (less spherical).[9] This shape indicates that this surface is easier to wet than a surface where the globules remain more spherical as for example, if the glass were covered with grease. When there is a greater attraction between the molecules of the surface and the water than between the water molecules themselves, the droplet flattens "and are said to wet the surface".[10] The surface tension of fountain solution can vary from 40 to 70 mN/m. However, fountain solutions having surface tension of 30 to 75 mN/m can also be run in lithographic presses.[11]

Wet repellency

"Wet repellency" is the inability of an ink to transfer to dampened paper (also called ink refusal). If the paper retains the water on the surface rather than absorbing rapidly, this surface water can interfere with ink transfer resulting in a "washed out" print that is at a lower density and exhibiting a grainy mottle.[12] Both wet repellency and wet pick can occur simultaneously.

Westvaco rod applicator

Westvaco rod applicator employs a disc with a groove of 15 micrometer. The surplus of ink or oil is metered off of the disc, leaving an ink layer of 10 to 12 micrometer, depending

on the rheological properties of the ink or oil.[13] This author employed the device only when oil was used to avoid the disadvantage when ink is used, that is, the thixotropic structure of the ink is not broken, as is the case with a roller system.[14]

The damping unit

The damping unit[15](see Figure 1)[16] used in the IGT apparatus consists of a anilox disc (1) which transfers the moisture film to the paper (2). First, an excess of water is applied to the disc, and then a doctor blade (3) reduces the quantity of water to the film thickness which is usual in offset. The excess of water is supplied by a small plug of cotton soaked in water placed on the disc before the doctor blade. The damping unit is provided with a weight (4) which exerts pressure on the doctor blade in order to keep it in contact with the damping disc. The damping unit is fixed to the printability tester by means of a pin (5) which is inserted in one of the mounting holes. The damping disc is placed on the top shaft of the printability tester and an inked printing disc applied to the lower shaft. The amount of water applied by the unit is between 0.2 to 0.3 micrometer and similar to that estimated as being used by a one-color offset press.[17] To simulate the situation of a four-color

offset lithographic process, a new type of dampening disc which applies thicker films has been developed. Figure 2 illustrates IGT Printability Tester AIC2-5 printing sector and printing discs. A time delay is introduced before the printed area C-D is overprinted with an inked rubber covered disc(Wheel 1).

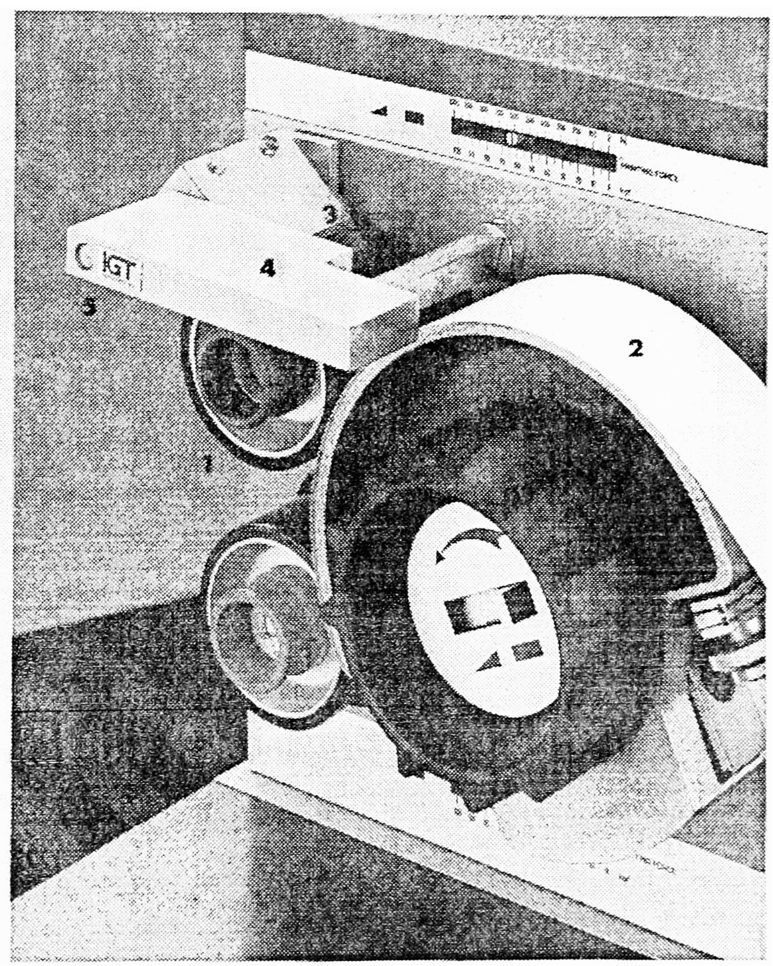

Figure 1. Damping Unit on an AIC2-5 Printability Tester

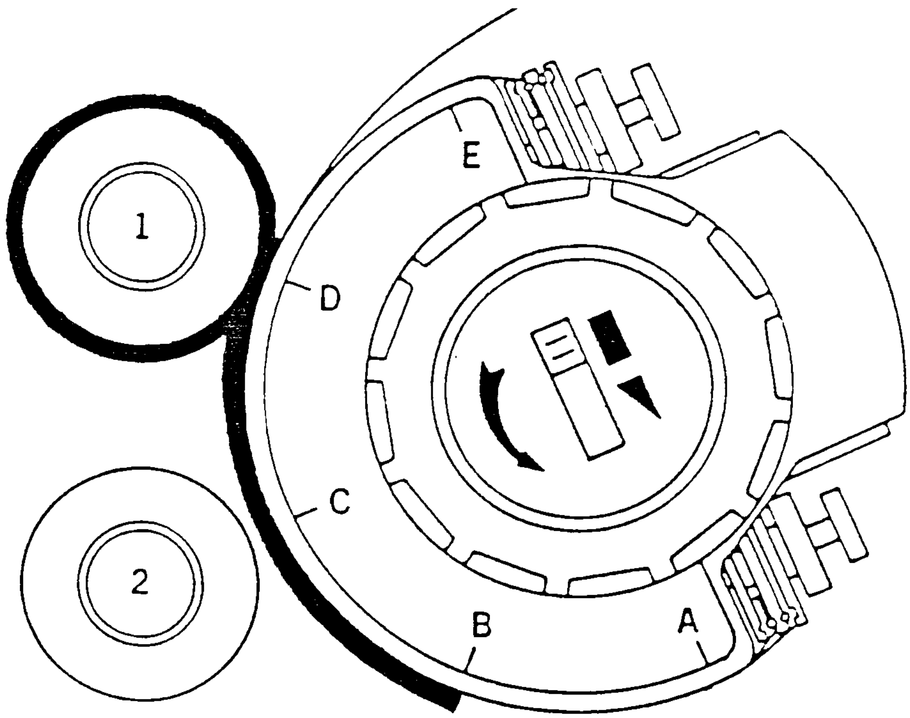

Figure 2. IGT AIC2-5 Printing Sector and Wheels

A-B: print from Disc 1

B-C: print from Disc 1 and Disc 2, with no time delay

C-D: print from Disc 1 and Disc 2, with time delay

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Endnotes for Chapter 2

1. Prof. Cliff Fraizer, interviewed by author, School of Printing Management and Sciences, Rochester Institute of Technology, New York, April 1992.

2. J.M. Fetsko, W.D. Schaeffer and A.C. Zettlemoyer, "Sources of Differences in Picking Results among presses", TAPPI, Vol. 46, No. 3, March 1963, p. 157.

3. Tadayosh Ide, "Studies on Picking", TAGA Proceedings, 1969, p466-467.

4. J.M. Fetsko, W.D. Schaeffer and A.C. Zettlemoyer, "Sources of Differences in Picking Results among Presses", TAPPI, Vol. 46, No. 3, March 1963, p. 161.

5. Ibid., p. 158.

6. D. H. Charlesworth and R. R. Coupe, PATRA Printing Laboratory Report, No. 40, 1961.

7. Equipment Catalogue, The Netherlands: Reprotest B.V., p. 21.

8. Arthur Beiser and Konrad B. Krauskopf, Introduction to Physics and Chemistry, New York: McGraw-Hill, 1969, p. 126.

9. Ian Faux, Modern Lithography, London, Macdonald and Evans, 1973, p. 10.

10. Ibid.

11 K. Schlapfer, "Wettability Phenomena and Their Significance in the Lithographic Printing Process", Advances in Printing, 1975, p. 88.

12. David A. Smith, Lois A. S. and Jeff W. M., "An Investigation of Coated Paper Wet Pick Using Scanning Electron Microscopy and the IGT Printability Tester", TAGA Proceedings, 1992, P. 345.

13. G.Blokhuis, "Testing the Surface Strength of Paper", IGT-Publication 35, The Netherlands: Reprotest B.V., 1979.

14. Ibid.

15. "A Closer Look: Wet Pick and Wet Repellence", Reprotest Bulletin, No. 9, April 1988.

16. Equipment Catalogue, The Netherlands: Reprotest B.V., p. 14.

17. Ibid.

Chapter 3

Literature Review

There is some controversy over how to measure the pick resistance of a paper primarily because there is no method of measurement accepted as a standard. Payne pointed out, in 1956, "that wet pick can often be avoided or alleviated by minimizing plate dampening and reducing ink tack on the press".[1] The tack of ink can be accurately controlled by using the inkometer.[2] Reed and Wheeler stated in 1953 "What has been lacking is an equally accurate instrument for measuring the pick resistance of paper. These two instruments, used together, should make it possible to control both ink and paper so as to eliminate completely all picking troubles on the press."[3] In 1989, Wester employed the IGT Printability Tester AIC2-5 to evaluate the wet pick and wet repellence tendency of paper. He concluded that the new dampening disc which applied thicker moisture film are very suitable to differentiate between good and excellent papers

with regards to wet pick and wet repellance tendency.[4] "Because of the larger moisture quantity wet pick and wet repellance will appear earlier in good papers than in excellent grades."[5] This author was investigating the effect of moisture quantity on wet pick. Based on Payne's and Wester's statements, good and bad paper can hopefully be differentiated by the new dampening disc in this study.

Bernstein investigated moisture pick test in his study. He stated "Since there is no easily determined standard of moisture application on the press, bench tests designed to simulate press conditions have not included moistening."[6] The double hammer assembly for the LTF Pick Tester has been utilized in applying very thin uniform films of moisture to paper surfaces just prior to making LTF Pick Tests with Tack Graded Inks. Comparisons of the degree and mode of failure of paper surfaces produced with and without dampening are shown by profile charts. He concluded : Profile charts used for "dry" pick tests are only partially applicable to "moisture" pick tests because the type of failure or degree of water receptivity of the paper may vary.[7] One of the disadvantages of the device is that the time interval between dampening and ink contact is approximately 7 seconds, which is much longer than desirable for simulation with press conditions.[8] Now with the IGT Printability Tester AIC2-5, the

delay time can be set to as low as 0.3 second. In 1959, Beckman performed a bench test on wet pick and wet curl. A pressure sensitive tape was used as a source of picking force. Wet pick is measured in the test by the loss in 75 degree specular reflectance of the paper surface, resulting from surface picking.[9] Numerical grading of wet pick has been accomplished using a 75 degree specular gloss instrument. An arbitrary Wet Pick Number, WPN, has been defined as below:[10]

$$WPN = (g / G) \times 100$$

$$WPN = 100 = \text{no measurable wet pick}$$

where:

g = the average 75 deg. gloss over the paper specimen area contacted by the tape.

G = the average 75 deg. gloss over the paper specimen area adjacent to the tape path.

Endnotes for Chapter 3

1. John, Payan, "Fountain Dope," New England Printer and Lithographer, Vol. 19, No 9, p. 35-36.

2. Robert F. Reed and Gordon C. Wheeler, The LTF Pick Tester for Offset Papers, New York: Lithographic Technical Foundation, Inc., 1953, p. 7.

3. Ibid.

4. Flip Wester, "Evaluation of Wet Pick and Wet Repellance Tendency of Paper with the IGT Printability Tester AIC2-5," TAGA Proceedings, 1989, p. 544.

5. Ibid.

6. Everett M. Bernstein, "Adaptation of the LTF Pick Tester for Moisture Pick Tests," TAGA Proceedings, 1963, p. 195.

7. Ibid., p. 204.

8. Ibid., p. 200.

9. N. Beckman, "A Banch Test for Predicting Effect of the Fountain Solution on Pick and Curl of Offset Papers," TAGA Proceedings, June 15-17, 1959, p. 63.

10. Ibid., p.60.

Chapter 4

Hypothesis

Two rolls of web paper are pre-sampled from the RIT press room on the basis of web press performance. One was found to exhibit the problem of wet pick and represents bad paper while the other did not exhibit this defect and represents good paper in this study. Appendix A contains additional information about these papers.

Hypotheses

This investigation has addressed the following hypotheses:

1. Null hypothesis:

   There is no significant difference in the failure of the paper surface of the good and bad paper due to the IGT dry surface strength test procedure.

1a. Alternative hypothesis:

There is a significant difference in the failure of the paper surface of the good and bad paper due to the IGT dry surface strength test procedure.

2. Null hypothesis:

There is no significant difference in the failure of the paper surface of the good and bad paper due to the wet pick and wet repellency technique with the IGT dampening unit using ink.

2a. Alternative hypothesis:

There is a significant difference in the failure of the paper surface of the good and bad paper due to the wet pick and wet repellency technique with the IGT dampening unit using ink.

3. Null hypothesis:

There is no significant difference in the failure of the paper surface due to the surface tension of the wetting fluid when using the IGT Printability Tester damping unit.

3a. Alternative hypothesis:

There is a significant difference in the failure of the paper surface due to the surface tension of the wetting

fluid when using the IGT Printability Tester damping unit.

4. Null hypothesis:

There is no significant difference in the failure of the paper surface due to the quantity of the wetting fluid applied.

4a. Alternative hypothesis:

There is a significant difference in the failure of the paper surface due to the quantity of the wetting fluid applied.

5. Null hypothesis:

There is no significant difference in the failure of the paper surface due to the interval time between dampening and printing when using the IGT Printability Tester damping unit.

5a. Alternative hypothesis:

There is a significant difference in the failure of the paper surface due to the interval time between dampening and printing when using the IGT Printability Tester damping unit.

Chapter 5

Methodology

Choosing the fountain solution

Three types of lithographic fountain solution concentrate were obtained, Rosos KSP #500, Rosos RV-1000 and Rosos G-7A-"V"-Comb Fountain Concentrate. Various concentration were made to obtain a solution with a low level of surface tension targeted at 32 dynes per cm. Measurement of surface tension for each solution was performed with a DuNouy Tensimoter, Model # 70545. The instrument was calibrated so that the dial reading was the apparent surface tension expressed in dynes per centimeter. If a known weight M is placed on the ring and balanced by the torsion in the wire, then the dial reading P is given by the equation

$$P = \frac{Mg}{2L}$$

Where

M = weight expressed in grams

g = value of gravity in cm/ sec^2

L = mean circumference of ring in centimeters

P = dial reading = apparent surface tension in dynes per cm

Six and a half ounces of the Rosos KSP #500 ASM-4 concentrate were added to one gallon of the tap water. The surface tension of this solution was measured to be 33.4 dynes per centimeter. Tap water was used as the wetting fluid with a high level of surface tension. The surface tension of tap water was measured to be 75.5 dynes per centimeter.

This study has been divided into two parts. The first part is a dry pick test on the IGT Printability Tester AIC2-5. The purpose of the tests was to find if there is a significant difference between the papers that were presampled by the press (which were mentioned previously in Chapter Four) on the basis of surface strength alone. Various speeds were tried to suit each side of the two tested papers. The sheet side facing outside on the paper roll was referred to as side A. The other side was referred to side B. On IGT Printability Tester AIC2-5, the recommended printing pressure is 125 N per cm. On IGT Printability Tester A2, normally the pick test is performed with a 1 cm wide printing disc and 35 kgf spring tension. In order to determine the adequate pressure, both 250 N and 40 Kgf were

tested on good paper, side A. The second part is the wet pick test. The experimental design (see Table 2) applied here is known as a complete factorial experiment. The factors under test were the:

1. Quantity of wetting fluid (Disc A applies a moisture film thickness of 0.2 micrometer. Disc B applies a moisture film thickness of 1.5 micrometer)
2. Surface tension of wetting fluid (33,4 dynes per centimeter for fountain solution, 75.5 dynes per centimeter for water)
3. Time interval between damping and printing (0, 0.3 and 0.6 second).

During the preliminary stages of test development, a sheet-fed offset ink was chosen over other inks because this researcher attempted to simulate the press room conditions. Printing speed was 1.6 m/sec for each test sample. Both samples of good paper and bad paper were tested with 0 second, 0.3 second, and 0.6 second time intervals.

Water absorbency tests were conducted to compare the water absorbency of the good and bad paper. One droplet of fountain solution and water was placed on these paper samples by a micro pipette. The time necessary for the droplet to disappear from the paper surface was used as the response for water absorbency.

Table 2. Experimental Design Used for Wet Pick Test

FACTORS		FOUNTAIN SOLUTION		WATER	
		Disc A (Thin Film)	Disc B (Thick Film)	Disc A (Thin Film)	Disc B (Thick Film)
INTERVAL TIME	0 Second	000	010	100	110
	0.3 Second	001	011	101	111
	0.6 Second	002	012	102	112

Equipment and materials used

Experiment 1

(1) Good paper and bad paper - "R" paper company

(2) IGT Pick Test Oil - medium

(3) Velocity chart

(4) Pin wrenchers

(5) Westvaco rod applicator

(6) IGT Printability Tester A2

(7) IGT Printability Tester AIC2-5

(8) Stereo microscope

Experiment 2

(1) Good paper and bad paper - Both manufactured by "R" paper company

(2) Os capiplus process black ink - Flint ink corporation

(3) IGT damping unit

- Dampening disc :

  Chromed A wheel 0.2 µm (Disc A)

  Chromed D wheel 1.5 µm (Disc D)

(4) Pin wrenchers

(5) IGT inking unit AE

(6) IGT ink pipette

(7) IGT Printability Tester AIC2-5

(8) Stereo microscope

Procedure and requirements

<u>Experiment 1</u>

Dry pick test

1. From the two rolls of good and bad paper cut ten representative test specimens 1x10 in free from abnormalities in grain direction. Do not touch the surface. Mark the specimens.

2. With the Westvaco rod applicator, constant film thickness is obtained.

a) Slide the grooved disc onto the printing - disc spindle until it snaps in the pin under the grooved disc.

c) Bring the wiper rod in contact with the grooved disc.

d) Insert the crank in the holes in the side of the grooved disc.

e) Distribute the oil over the grooved disc by turning it anti clockwise a number of times, until the oil film appears to be uniform.

f) Remove the lever with weight, and take away the crank from the grooved disc.

3. Attach a test strip to the sector.

4. Mount the grooved disc on the bottom shaft IGT Printability Tester AIC2-5 and turn it in such a position that the point where the rod was lifted off coincides with the beginning of the print.

5. Put the printing disc in action and make a print at increasing speed.

6. Each strip was placed along the horizontal axis of the velocity chart so that the start of the print coincides with the zero point of the distance scale. Read the velocity at which picking begins.

7. Repeat until six specimens for good and six specimens for bad paper have been tested.

Experiment 2

Wet pick test:

1. Inserting cotton

a) Take a wad of cotton and wet it thoroughly.

b) Roll it between your fingers into a rod of 2 to 3 mm in diameter.

c) Cut the roll to the width of the damping disc.

d) Lift the doctor blade, place the cotton-wool on the disc. Lower the doctor blade, and by turning the damping disc bring the piece of cotton-wool into the nip between doctor blade and damping disc.

2. Apply a printing pressure of 125 N / cm on both shafts (The top shaft with damping disc and the bottom one with the printing disc that has not yet been inked up).

3. Remove the pressure from both shafts, take the printing disc off the shaft, for inking.

4. Adjust the required time delay, where applicable.

5. Place a strip of the paper to be tested on the covered printing sector.

6. Put the sector in its starting position and place an inked-up printing disc on the bottom shaft.

7. Apply pressure again to both shafts and make a print, immediately.

Method of statistical analysis

To analyze whether the result differences are caused by factor influence or experimental error, the statistical procedure "Analyses of Variance (ANOVA)" is used for experiment 1. Minitab, a statistical software, is used to calculate the ANOVA table.

The hypothesis is:

Hypothesis 1: $H_0: \mu_1 = \mu_2$

1a: $Ha: \mu_1 \neq \mu_2$

μ_1 = the population mean of critical picking velocity for dry pick test using good paper

μ_2 = the population mean of critical picking velocity for dry pick test using good paper

The null hypothesis 1 is tested using an F test at a level of confidence of 95% ($\alpha = 0.05$). The null hypothesis 1 is rejected if the F derived from ANOVA is greater than the tabulated F value.

Data measurement and calculation

For experiment 1, the starting point of the pick phenomenon for each test strip was determined by the use of Stereo microscope and the starting point of the complete rupture was detected by the unaided eye. Wet pick tests with IGT oil were attempted but wet repellence was found. Accelerating velocity was first used to determine the critical picking velocity for wet pick test using ink. Due to the limitation of the apparatus no velocity could be measured and constant speed of 1.6 m/sec were applied instead. According to the

phenomenon observed, no numerical response could be obtained for statistical analysis. A comparison of the visual aspect of the test specimen were used. The result was evaluated on the last part of the strip, which has been wetted with a time delay if applied. To differentiate between wet pick and wet repellence, the printing disc was also examined using Stereo microscope. In case of wet pick, paper particles could be observed on the printing disc. This is not the case when wet repellence caused a defect in the print. All measurements will be carried out in a room maintained at 23.0° +/- 1 °C and 50.0% +/- 2.0% RH.

Chapter 6

The Results of The Experiments

The test results for experiment 1 were analyzed using statistical methods. Table 3 is a summary of the results for a preliminary experiment. The conclusions of the t test calculations are presented in Table 4. The velocities of the starting point for fiber picking and for complete rupture for both papers are given in Table 5 and 6. The VVP responses of the starting point for fiber picking and complete rupture for both papers are given in Table 7 and 8. The conclusions of the ANOVA calculations for each response are presented in the ANOVA Summary Tables 9 and 10.

Based on Table 4, the result of the t test, the computed value of t, 0.26, is smaller than the tabulated value of t, 2.132. This indicates that there is no significant difference between the sample means of the velocity at which complete rupture begins when 250 N and 40 Kgf of pressure applied (on side A of good paper). On this basis we may

conclude that printing pressure does not influence picking tendency for this test. As a result, it was decided to follow the recommended pressure, 125 N for 1 cm, for the IGT Printability Tester AIC2-5.

Table 3.Summary of Printing Pressure Results
Velocity at Complete Rupture Point
(Good Paper, Side A)

PRINTING FORCE	250 N	40 KGF
METER/SECOND	1.91	1.91
	1.63	1.63
	1.77	1.91

Table 4. T Test Summary Table Effect of Printing Force on the IGT Response for Complete Paper Rupture

PRINTING FORCE	MEAN	STDEV	SE MEAN
250 N	1.77	0.14	0.0808
40 KGF	1.817	0.162	0.0933

H_0: $\mu_{250N} = \mu_{40kgf}$ H_a: $\mu_{250N} \neq \mu_{40kgf}$

μ indicates the mean of the population.

$t = -0.38$ $t_{0.05,4} = 2.132$

From the ANOVA table 9 and 10, The table f ratio at the 0.05 level of significance is 5.12 for both paper kind and paper side. For the starting point of fiber picking, the ANOVA Summary Table (Table 9) indicates that paper kind ($F = 115.67 > 5.12$) had a significant effect on the VVP response. Paper side ($F = 1.00 < 5.12$) did not have a significant

statistical effect on VVP. For the starting point of complete rupture, the ANOVA Summary Table (Table 10) indicates that the kind of paper ($F = 164.27 > 5.12$) had a significant effect on the VVP response. Paper side ($F = 4.38 < 5.12$) is shown to have no significant statistical effect on VVP. Since the two sets of data reduce to the same statistical result, we can conclude that the side of paper printed does not have a significant effect on the resulting VVP. This author will therefore test one side of the paper in continuing this study. Side A for both paper samples were used for the remainder of this investigation.

The difference between the variance of the VVP of the good paper and the variance of the VVP of the bad paper is significant, therefore, null hypothesis number 1, "There is no significant difference in the failure of the paper surface of the good and bad paper due to the IGT dry surface strength test procedure" is rejected. The alternative hypothesis for this is "There is a significant difference in the failure of the paper surface of the good and bad paper due to the IGT dry surface strength test procedure".

Table 5. Summary of Experimental Results
Velocity at Pick Starting Point

PAPER	GOOD		BAD	
SIDE	A	B	A	B
Meter/Second	1.45	1.28	0.39	0.41
	1.27	1.17	0.48	0.64
	1.27	1.01	0.54	0.47

Table 6. Summary of Experimental Results
Velocity at Complete Rupture Point

PAPER	GOOD		BAD	
SIDE	A	B	A	B
Meter/Second	2.09	1.83	0.91	0.95
	2.00	1.63	0.95	0.95
	1.91	1.59	0.91	0.93

Table 7. Summary of Experimental Results
VVP Response of Pick Starting Point

PAPER	GOOD		BAD	
SIDE	A	B	A	B
VVP	75.40	66.56	20.28	21.32
	66.04	60.84	24.96	33.28
	66.04	52.52	28.08	24.44

Table 8. Summary of Experimental Results
VVP Response of Complete Rupture Point

PAPER	GOOD		BAD	
SIDE	A	B	A	B
VVP	108.68	95.16	47.32	49.40
	104.00	84.76	49.40	49.40
	99.32	82.68	47.32	48.36

Table 9. ANOVA Summary Table for VVP Response of Pick Srarting Point

Source	Sum of Squares	df	Mean Squares	F Ratio (Calculated)	F Ratio (Tabulated)	Significancy
Paper	4603.6	1	4603.6	115.67	5.12	Yes
Side	39.7	1	39.7	1.00	5.12	No
Error	358.2	9	39.8			
Total	5001.6	11				

Table 10. ANOVA Summary Table for VVP Response of Complete Rupture Point

Source	Sum of Squares	df	Mean Squares	F Ratio (Calculated)	F Ratio (Tabulated)	Significancy
Paper	6693.0	1	6693.0	164.27	5.12	Yes
Side	178.5	1	178.5	4.38	5.12	No
Error	366.7	9	40.7			
Total	7238.1	11				

Table 11 gives the result wet pick tests on good and bad paper with no time interval between the application of water and ink. Table 12 shows the results of the water absorbency tests due to good and bad paper. Table 13 indicates the results of the wet pick tests on good and bad paper when a 0.3 second and 0.6 second time interval between dampening and printing is set on the IGT Printability Tester AIC2-5. This table provides some interesting results. When disc A (smaller quantity of fluid) was used, whether fountain solution or water was applied, the bad paper results in wet pick while the good paper shows ink repellence. Thus, hypothesis number 2, "There is no significant difference in the failure of the paper surface of the good and bad paper due to the wet pick and wet repellency technique with the IGT dampening unit using ink" can be rejected. The alternative hypothesis for this is "There is a significant difference in the failure of the paper surface of the good and bad paper due to the wet pick and wet repellency technique with the IGT dampening unit using ink". In this case this difference confirms with that predicted by the printing press.

When disc B (larger quantity of fluid) was used, whether fountain solution or water, both good paper and bad paper produce the same defect: fountain solution applied by Disc B results in some wet pick with wet ink repellence; water

applied by Disc B results in wet repellence. In this case wet repellence indicates the ink film refuses to transfer to the paper surface.

Table 13 indicates that wet repellence, the refusal of the ink to transfer, ceases to occur. The defect is now shown to be wet pick. There is no defect indicated when a thinner film of fountain solution is applied at the 0.6 second time interval. Disc B (larger quantity of fluid) produces a significantly more severe wet pick than Disc A (smaller quantity of fluid). When Disc A (smaller quantity of fluid) is used, the printed samples dampened with water show more severe wet pick than that dampened with fountain solution for the 0.3 and 0.6 second time intervals for both kinds of paper. When Disc B (larger quantity of fluid) is used, there is a different result, the printed samples dampened with fountain solution show more severe wet pick than the prints where water was used for the 0.3 and 0.6 second time intervals for both kinds of paper. Therefore, the null hypothesis number 3, "There is no significant difference in the failure of the paper surface due to the surface tension of the wetting fluid when using the IGT Printability Tester damping unit." is rejected. The alternative hypothesis for this is "There is a significant difference in the failure of the paper surface due to the

surface tension of the wetting fluid when using the IGT Printability Tester damping unit".

Tabel 11. Summary of Experimental Results Wet Pick Test
No Time Interval Between Application of Water and Ink

FACTORS	FOUNTAIN SOLUTION		WATER	
	Disc A (Thin Film)	Disc B (Thick Film)	Disc A (Thin Film)	Disc B (Thick Film)
GOOD PAPER	Repellence	Major: Repellence Minor: Pick	Repellence	Repellence
BAD PAPER	Pick	Major: Repellence Minor: Pick	Pick	Repellence

Table 12. Summary of Experimental Results
Water Absorbency Test

	FOUNTAIN SOLUTION	WATER
GOOD PAPER	7'36"	9'11"
BAD PAPER	3'53"	1'36"

Table 13. Summary of Experimental Results Wet Pick Test (Both Good Paper and Bad Paper)

FACTORS		FOUNTAIN SOLUTION		WATER	
		Disc A (Thin Film)	Disc B (Thick Film)	Disc A (Thin Film)	Disc B (Thick Film)
INTERVAL TIME	0.3 Second	Pick	Strong Pick	Pick	Strong Pick
	0.6 Second	No Effect	Strong Pick	Pick	Strong Pick

Appendix B compare the wet pick results when Disc A and Disc B are used. It is apparent that Disc B causes more severe paper surface failure (see also Table 12 and 13). The increase in moisture film thickness results in an increased wet pick at 0.3 and 0.6 time interval. Therefore, the null hypothesis 4, "There is no significant difference in the failure of the paper surface due to the quantity of the wetting fluid applied." is rejected. The alternative hypothesis for this is, "There is a significant difference in the failure of the paper surface due to the quantity of the wetting fluid applied."

Appendix C compare the influence of the interval times. It shows that increasing the interval time results in a decrease in the failure of the paper surface. Wet pick decreases when the interval time increases from 0.3 to 0.6 second. Therefore, the null hypothesis 5, "There is no significant difference in the failure of the paper surface due to the interval time between dampening and printing when using the IGT Printability Tester damping unit." is rejected. The alternative hypothesis for this is "There is a significant difference in the failure of the paper surface due to the interval time between dampening and printing when using the IGT Printability Tester damping unit."

Data analysis and discussion

The conclusion drawn from Table 4 confirms the idea "the influence of the pressure is not great"[1]. This is also shown by Figure 3.[2] It was reported that bad paper exhibited wet pick in web offset press room while the good paper did not exhibit the defect. From Table 9 and 10, we found there was a significant difference between these two kinds of paper using the conventional IGT surface strength test with no dampeningfluids. Table 5 shows the bad paper has poor surface strength. This paper is not as strong even before wetting. This would lead one to suspect that the problem happened in press room was not purely a "wet pick" problem but a problem of the surface strength of this paper.

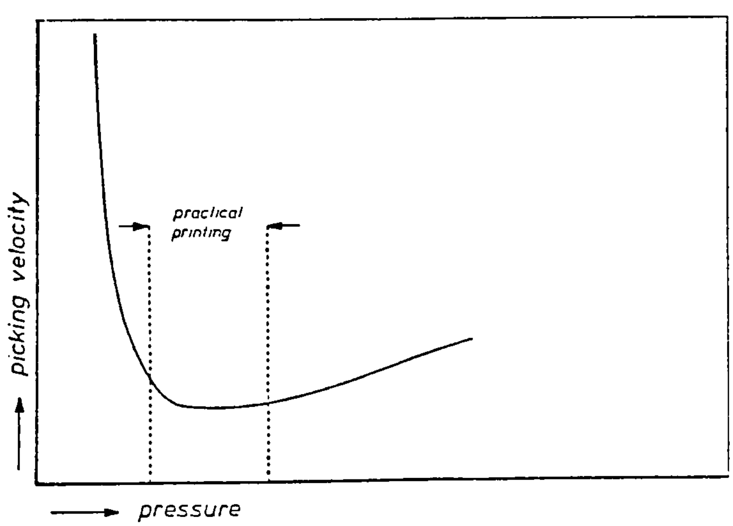


Figure 3. Relation Between Printing Pressure and Picking Velocity

Wet pick tests conducted with no time interval yields results different from those with 0.3 second and 0.6 second interval time. Good paper and bad paper is shown to be different when using thinner fluid film and no interval time. Table 11 shows the good paper exhibits wet repellence except when Disc B (thicker fluid film) and fountain solution are used. It can be hypothesized that good paper does not absorb dampening solution unless the amount of the dampening solution is large and the surface tension of the dampening solution is low when no interval time applied. Bad paper exhibits wet repellence only with high damping film thickness and fountain solution. It exhibits wet pick in all other situations. This may be because the dampening solution penetrates into the bad paper more quickly than the good paper. Table 12 shows evidence for this conclusion. Bad paper is affected even when a small quantity of water is applied. When the amount of dampening solution increases, the result changes to wet repellence. It appears that the dampening solution applied exceeds some upper limit, it does not absorb the dampening film, retains the dampening solution on its surface to cause wet repellence.

Table 13 shows that wet pick increases when the quantity of the wetting fluid increase.

Endnotes for Chapter 6

1. G.Blokhuis, "Testing the Surface Strength of Paper", IGT-Publication 35, 1979, p. 17

14. Ibid., p. 18.

Chapter 7

Summary and Conclusions

(1) The bad paper, which was reported to exhibit wet pick on a web press was found to have low surface strength using the IGT surface strength test procedure. There is evidence to reject null hypothesis number 1, "There is no significant difference in the failure of the paper surface of the good and bad paper due to the IGT dry surface strength test procedure". There is a significant difference in surface strength between the bad paper and good paper. The good paper was reported to be free of the wet pick problem on the web offset printing press.

(2) Good paper and bad paper operate on the IGT Printability Tester AIC2-5 in a manner similar to that predicted on press when a moisture film (fountain solution or water) of 0.2 μm is applied with no delay between application of ink and water. Bad paper shows wet pick while good paper shows wet repellence. There is evidence to reject hypothesis number 2,

"There is no significant difference in the failure of the paper surface of the good and bad paper due to the wet pick and wet repellency technique with the IGT dampening unit using ink". This researcher believes that this method can be used to predict the defect referred to as wet pick.

(3) Wet repellence at the interval time of 0 second changes to wet pick without wet repellence at the interval time of 0.3 second in both papers. An explanation for this may be that the time lapse between the dampening and printing allows the water the time to penetrate and weaken the paper surface.

(4) Adding to the moisture film thickness results in an increased wet pick in both good and bad paper with a delay between dampening and inking of 0.3 and 0.6 second. There is evidence to reject the null hypothesis 4, "There is no significant difference in the failure of the paper surface due to the quantity of the wetting fluid applied".

Chapter 8

Observation and Recommendation

(1) Wet pick tests with IGT oil were attempted but wet repellence was found. One question thus was raised: Is that the reason why IGT did not recommend wet pick tests with IGT oils?

(2) Good paper does not absorb dampening solution unless the amount of the dampening solution is large and the surface tension of the dampening solution is low at no interval time. Dampening solution, in small quantity, penetrates into bad paper so quickly that at no interval time wet pick can occur. When larger quantity of wetting fluid applied on bad paper, the defect changed from wet pick to wet repellence because it appears that the amount of fluid exceeds the limit that the paper can absorb at no interval time. The moisture film retained on the surface interfere with ink transfer resulting in wet repellence.

(3) From figures C-1 and C-2 it can be found that as the interval time increases picking decreases. This may be due to evaporation of the wetting fluid. There is evidence to reject the null hypothesis 5, "There is no significant difference in the failure of the paper surface due to the interval time between dampening and printing when using the IGT Printability Tester damping unit".

(4) When the amount of wetting fluid applied on paper prior to printing is small, water causes more severe wet pick than fountain solution. When the amount of wetting fluid applied on paper prior to printing is larger, fountain solution causes more severe wet pick than water. This author hypothesized that when the quantity of wetting fluid applied on paper is smaller, the fountain solution forms a continuos thin film due to low surface tension while water forms droplets due to high surface tension. Thus, fountain solution has greater surface area to evaporate and causes less picking. However, when paper is wetted with more wetting fluid, the effect of the wetting characteristic is more significant than the evaporation of the fountain solution. The surface tension of fountain solution is lower than water, so it can wet the paper surface better than water thus causes more severe picking. There is evidence to reject the null hypothesis number 3, "There is no significant

difference in the failure of the paper surface due to the surface tension of the wetting fluid when using the IGT Printability Tester damping unit". Consequently, it can be hypothesized that for a wetting fluid, the factors that contribute to picking are the quantity, the evaporation rate, and the wetting characteristic. This should be studied in future investigation.

(5) The time interval between the application of two colors for four color sheet-fed presses is 0.1 to 3.0 seconds, for four color web presses, 0.03 to 1.0 seconds. Wet pick is most likely to occur on the third and last printing units, where ink tack is low. Further investigation can be conducted by using low tack ink at full range of the interval time.

Bibliography

Beckman, N. "A Banch Test for Predicting Effect of the Fountain Solution on Pick and Curl of Offset Papers," TAGA Proceedings, 1959.

Beiser, Arthur and Krauskopf, B. Konrad, Introduction to Physics and Chemistry, New York: McGraw-Hill, 1969.

Bernstein, M. Everett "Adaptation of the LTF Pick Tester for Moisture Pick Tests," TAGA Proceedings, 1963

Blokhuis, G. "Testing the Surface Strength of Paper," IGT-Publication 35, 1979.

Bruno, Michael Working with Paper: a Guide for Printers, New York: NAPL, 1977.

Bureau, H. William What the Printer Should Know About Paper, Pittsburgh: GATF, 1982.

Charlesworth, H. D. and Coupe, R. R. PATRA Printing Laboratory Report, No. 40, 1961.

Faux, Ian Modern Lithography, London: Macdonald and Evans, 1973.

Fetsko, J. M., Schaeffer W. D. and Zettlemoyer, A. C. "Sources of Differences in Picking Results among presses", TAPPI, Vol. 46, No. 3, March 1963.

Fraizer, Cliff interviewed by author, School of Printing Management and Sciences, Rochester Institute of Technology, New York, April 1992.

Ide, Tadayosh "Studies on Picking," TAGA Proceedings, 1969.

Payan, John "Fountain Dope", New England Printer and Lithographer, Vol. 19, No 9.

Reed, F. Robert and Wheeler, C. Gordon "The LTF Pick Tester for Offset Papers," New York: Lithographic Technical Foundation, Inc., 1953.

Righadl, M. Borg, J. Skeppstedt, A., Malhammar G.and Engstrom, "Surfce Treatment of $CaCO_3$ with Polymers in Order to Improve the Surface Strength of Coated Papers," TAPPI Coating Conference, 1978.

Schlapfer, K. "Wettability Phenomena and Their Significance in the Lithographic Printing Process," Advances in Printing, 1975.

Smith, A. David, S. A. Lois and M. W. Jeff "An Investigation of Coated Paper Wet Pick Using Scanning Electron Microscopy and the IGT Printability Tester," TAGA Proceedings, 1992.

Wester, Flip "Evaluation of Wet Pick and Wet Repellance Tendency of Paper with the IGT Printability Tester AIC2-5," TAGA Proceedings, 1989.

"A Closer Look: Wet Pick and Wet Repellence," Reprotest Bulletin, No. 9, April 1988.

Surface Strength of Technology, Atlanta: TAPPI Inc., 1983

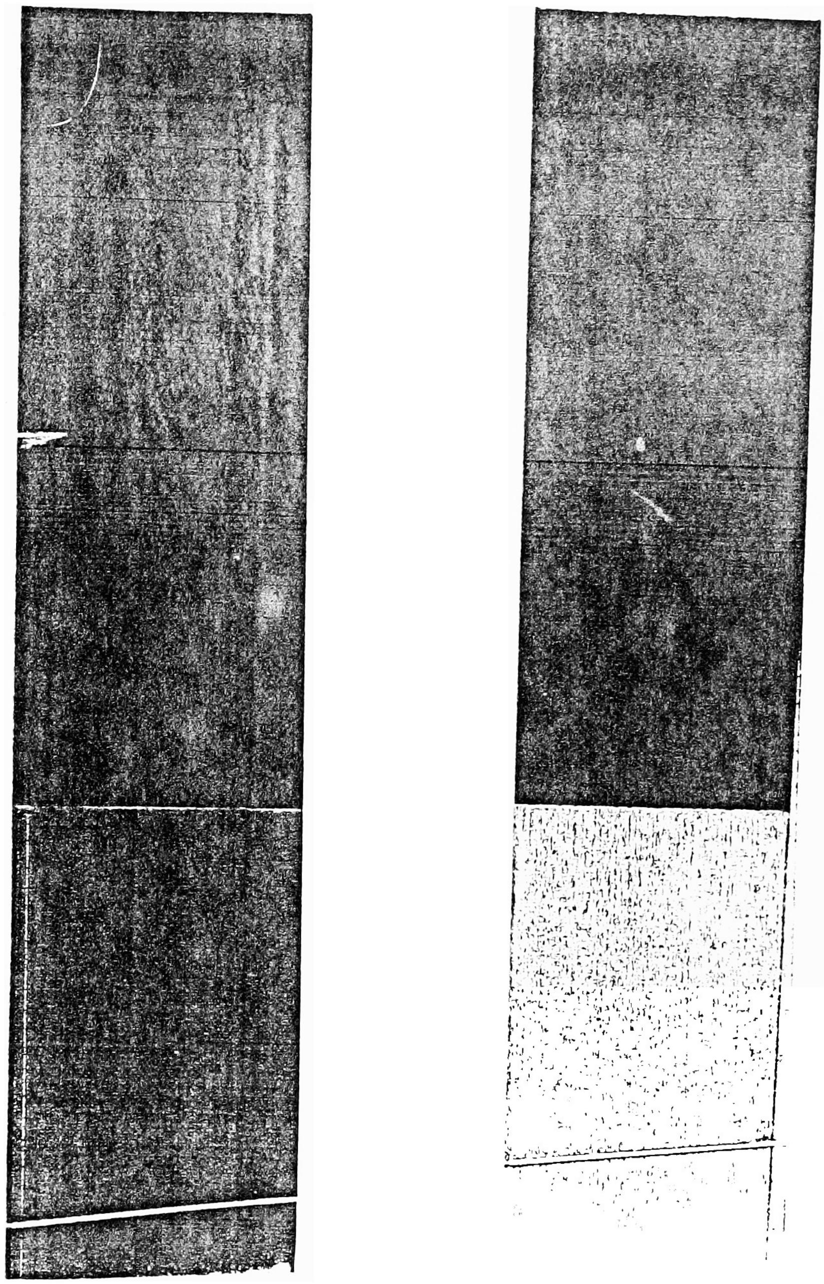
Appendix A

Information of the paper used

	Good Paper	Bad Paper
Grade - Finish	Max Gloss	Econoweb Gloss
Basis Weight	45 lbs	35 lbs

Appendix B

Comparison of the influence of Disc A and Disc B

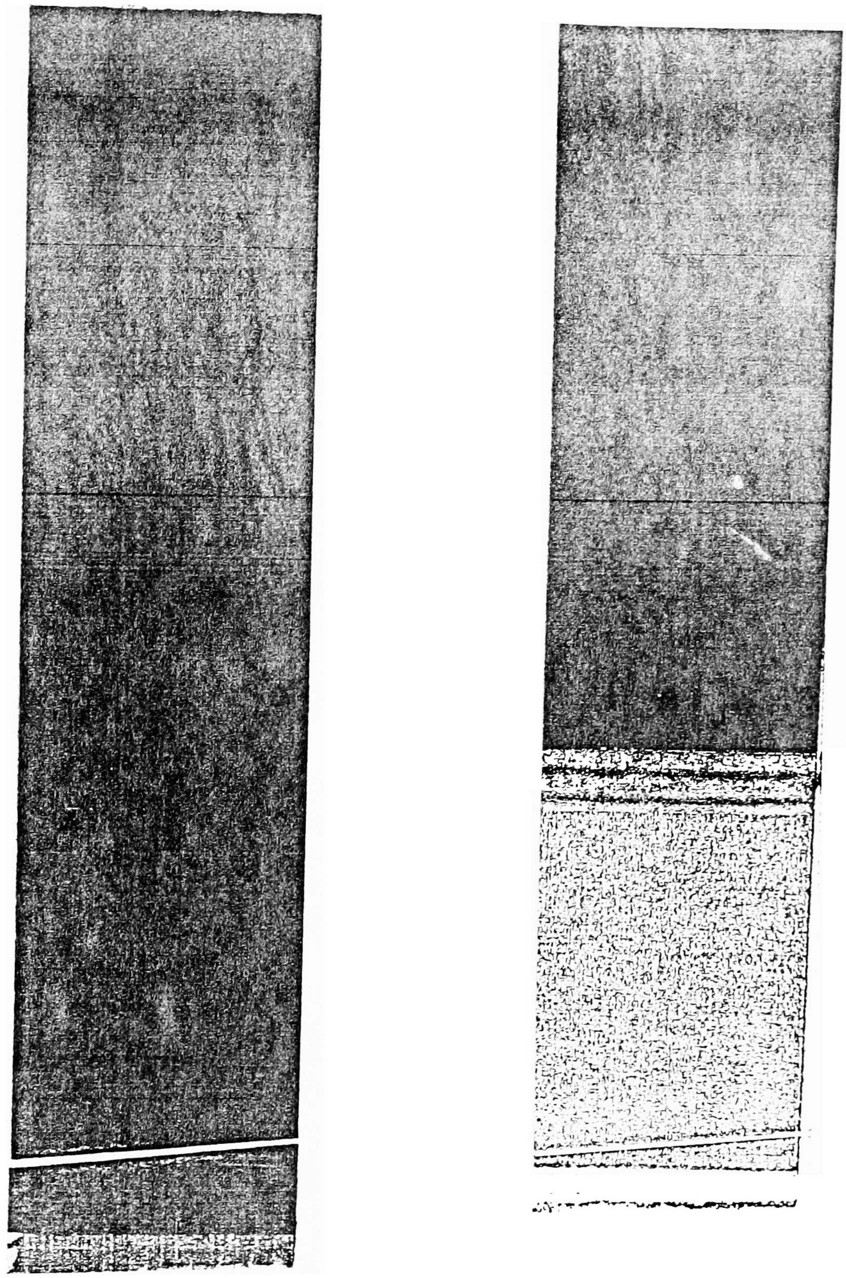


left: Disc A right: Disc B

Figure B-1. wetting fluid: fountain solution

interval time: 0 second

paper: good

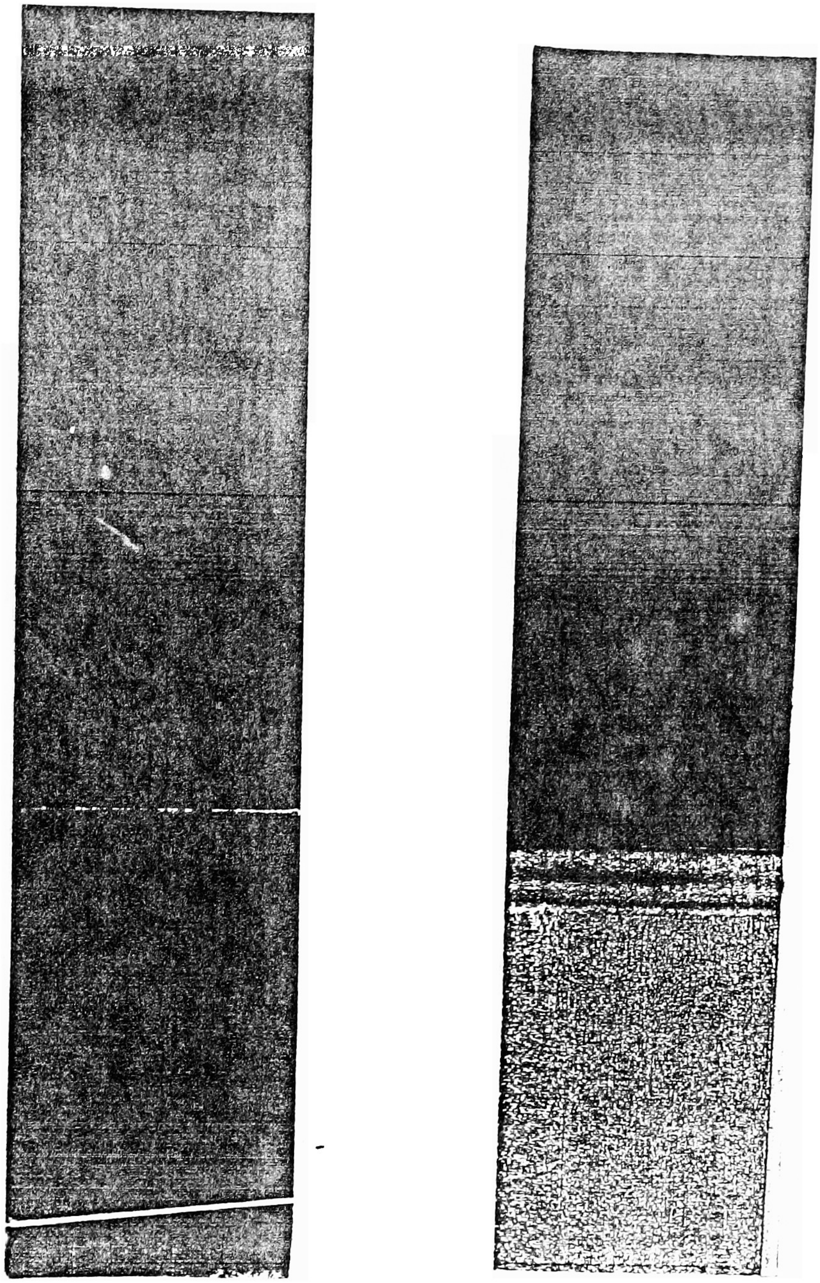


left: Disc A   right: Disc B

Figure B-2.   wetting fluid: fountain solution

interval time: 0.3 second

paper: good

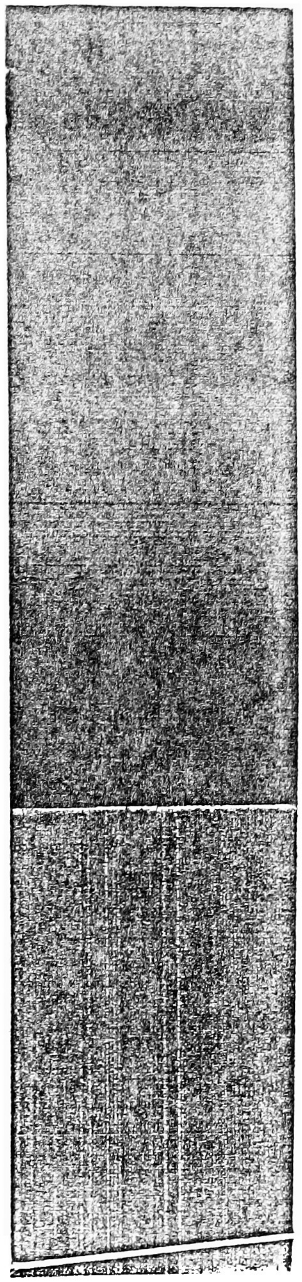


left: Disc A right: Disc B

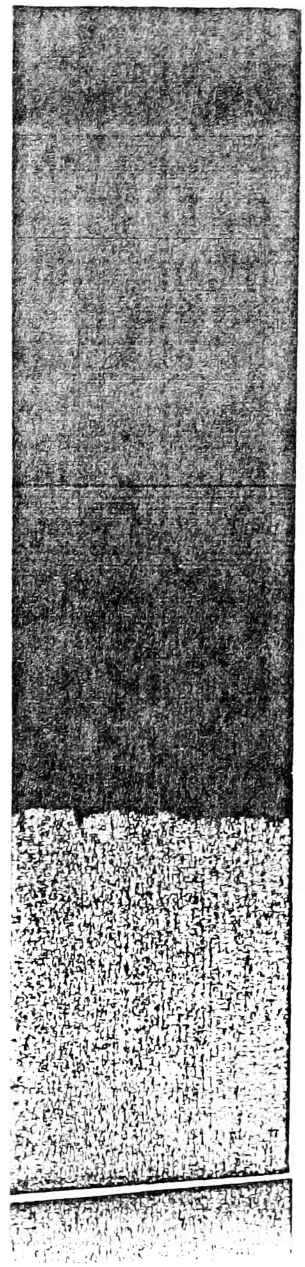
Figure B-3. wetting fluid: fountain solution

interval time: 0.6 second

paper: good



left: Disc A

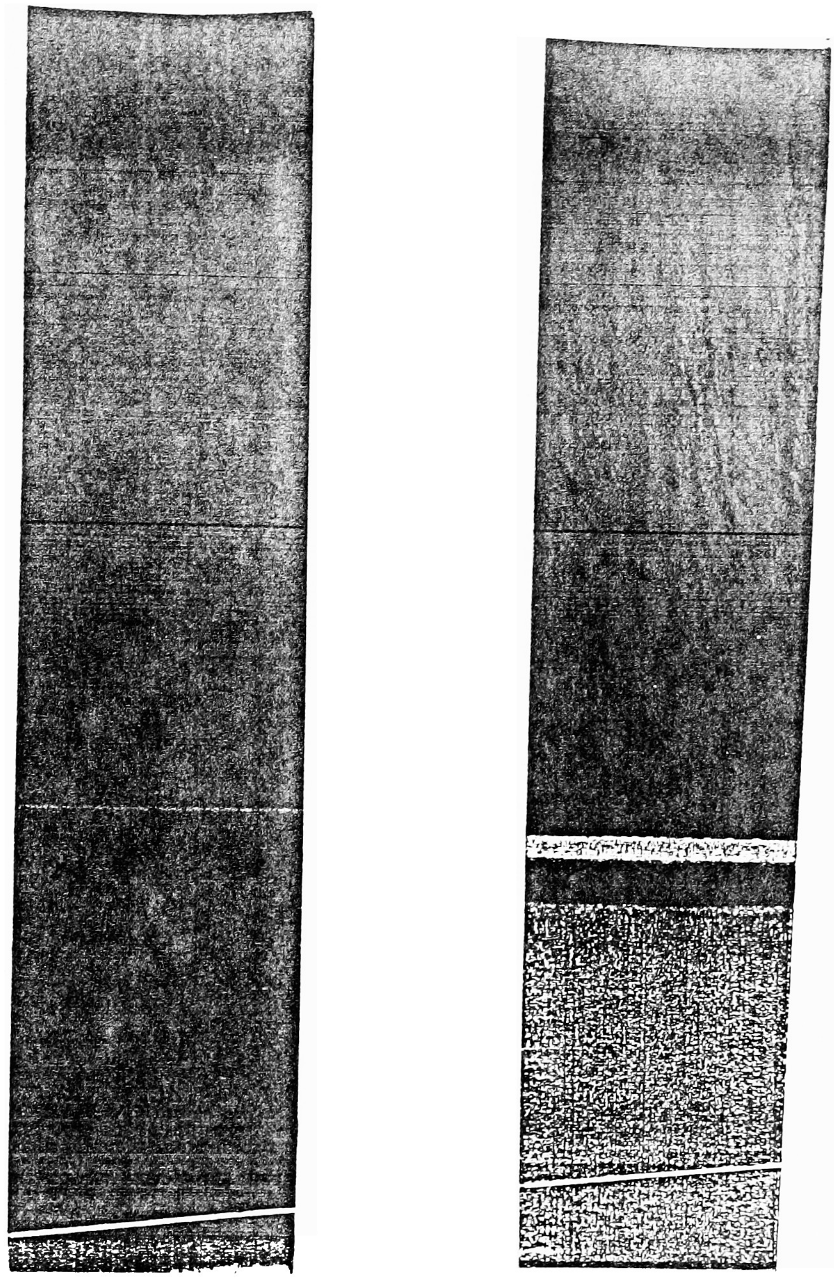


right: Disc B

Figure B-4. wetting fluid: fountain solution

interval time: 0 second

paper: bad

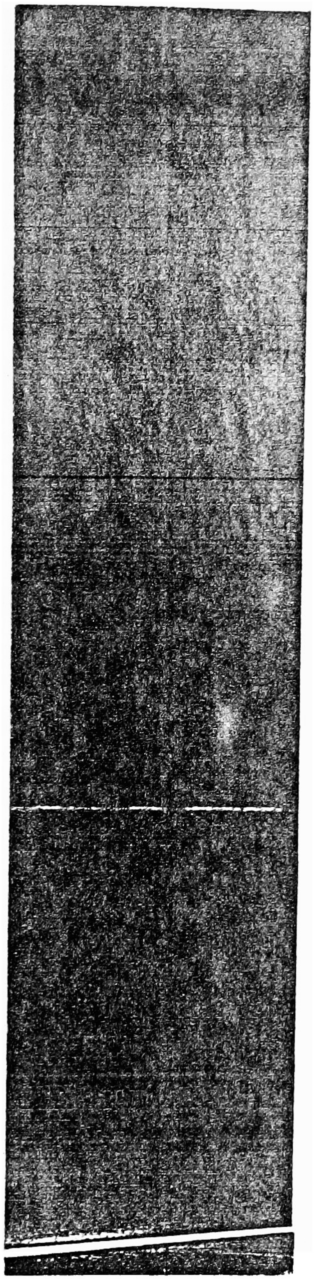


left: Disc A right: Disc B

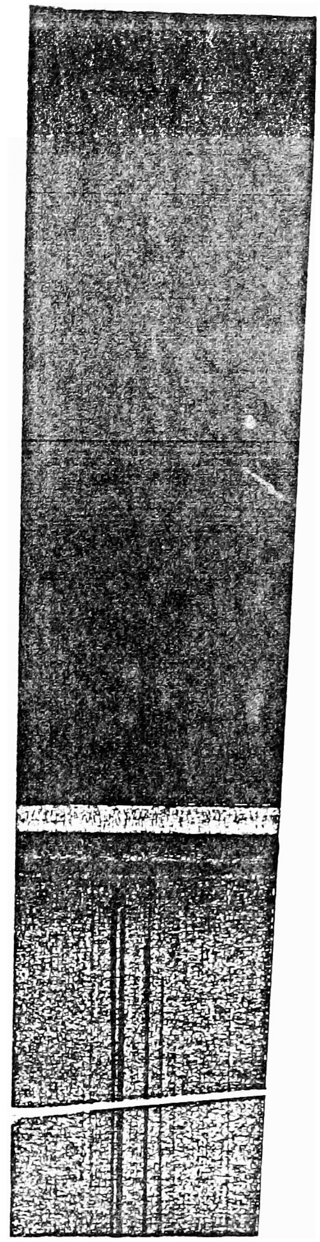
Figure B-5. wetting fluid: fountain solution

interval time: 0.3 second

paper: bad



left: Disc A

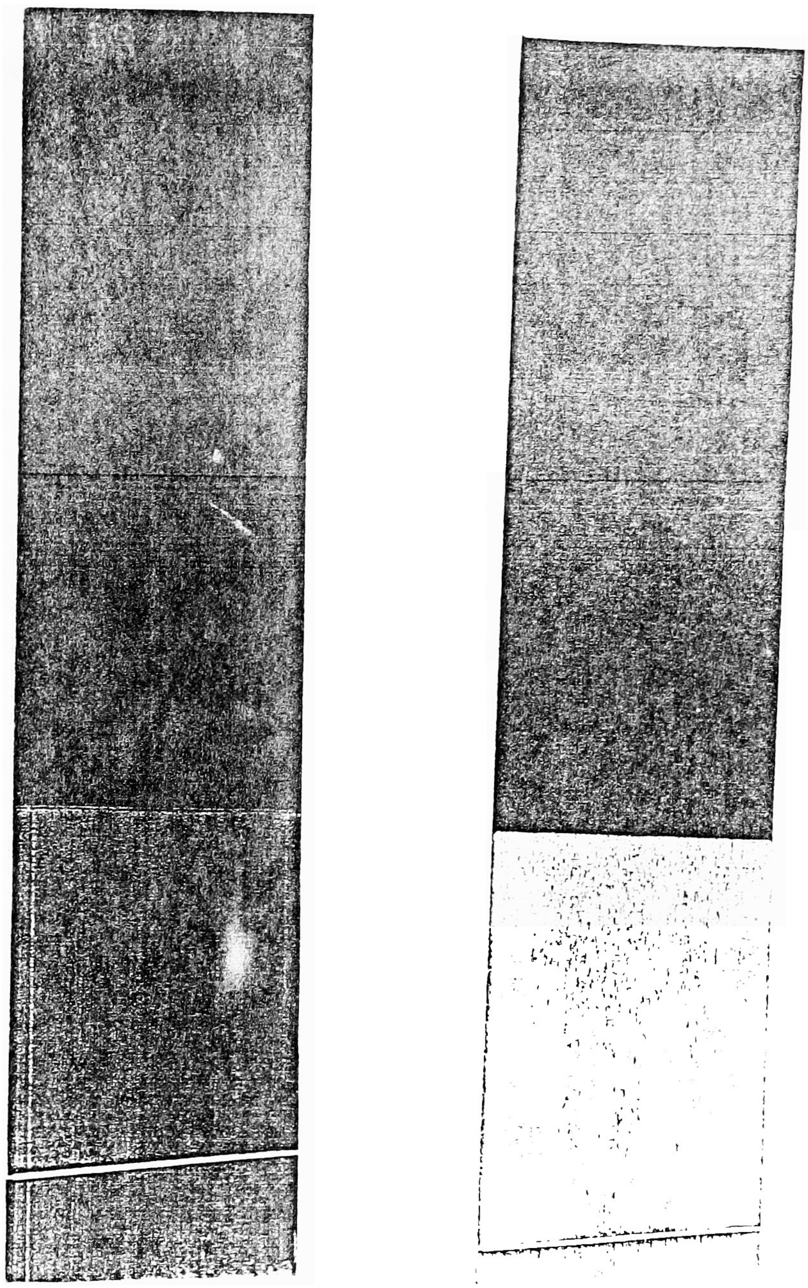


right: Disc B

Figure B-6. wetting fluid: fountain solution

interval time: 0.6 second

paper: bad

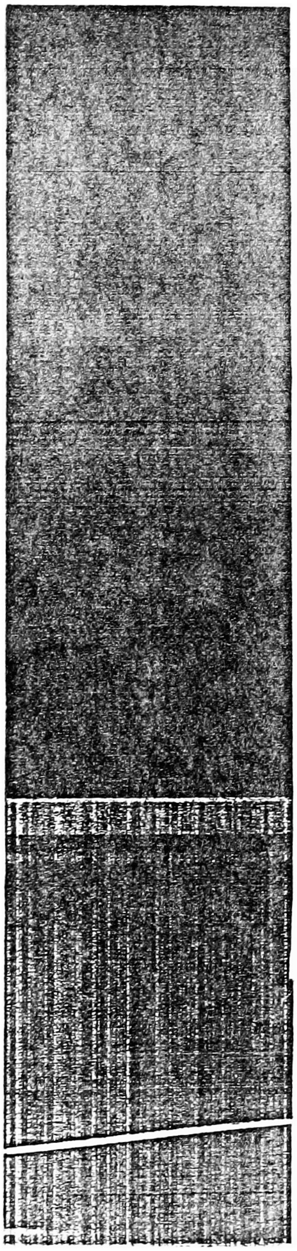


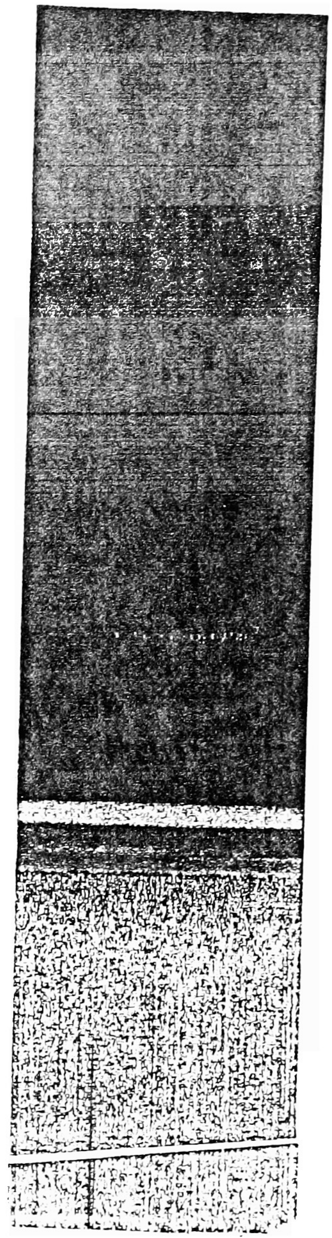
left: Disc A right: Disc B

Figure B-7. wetting fluid: water

interval time: 0 second

paper: good



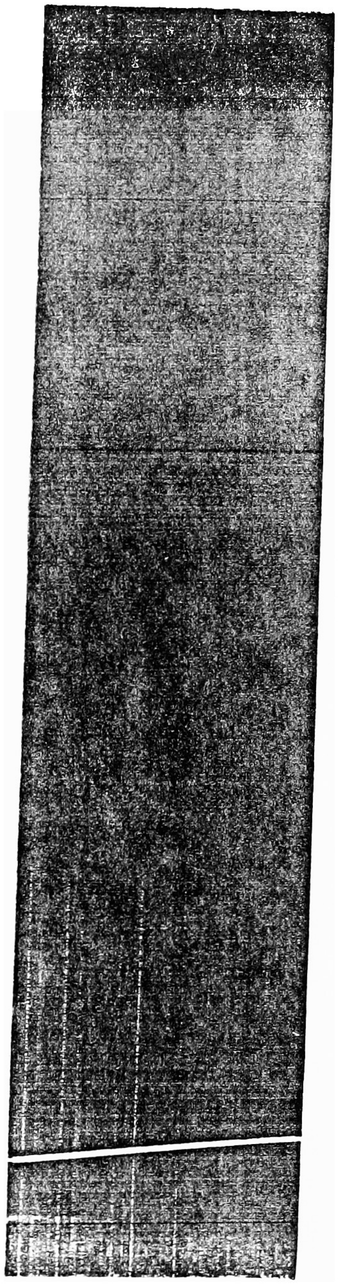


left: Disc A right: Disc B

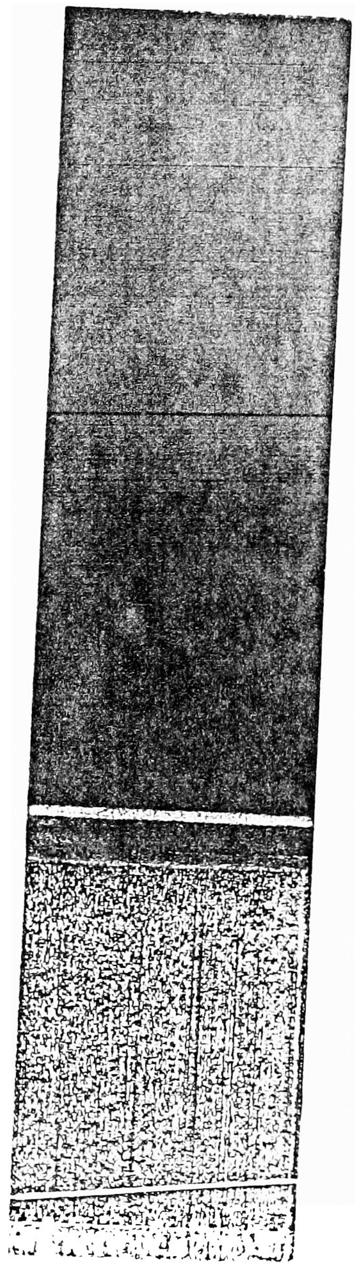
Figure B-8. wetting fluid: water

interval time: 0.3 second

paper: good



left: Disc A

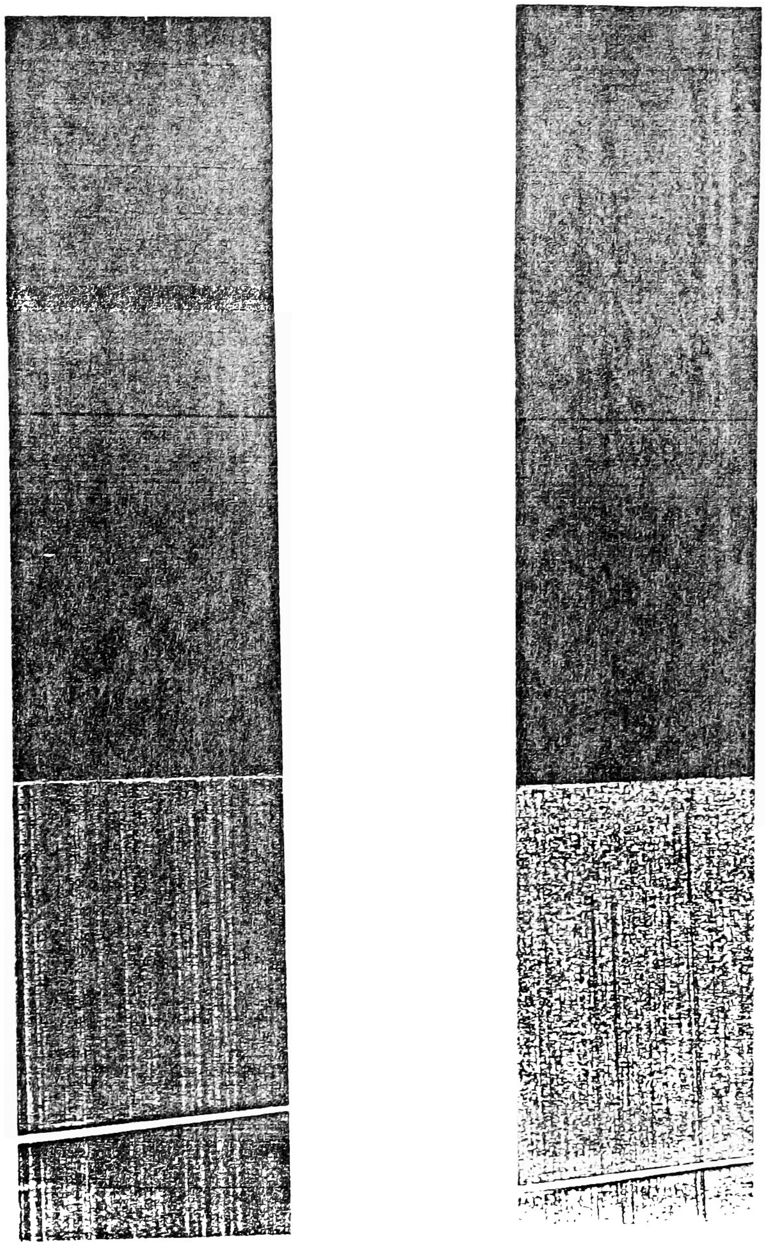


right: Disc B

Figure B-9. wetting fluid: water

interval time: 0.6 second

paper: good

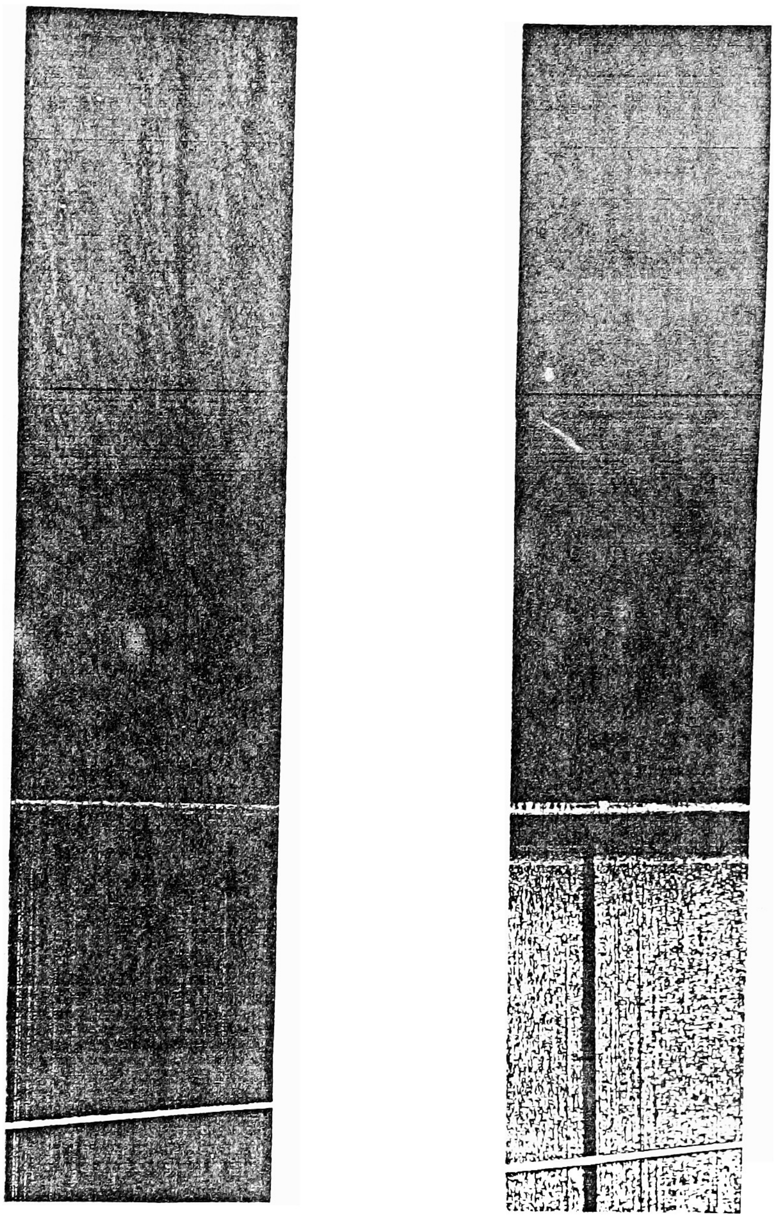


left: Disc A right: Disc B

Figure B-10. wetting fluid: water

interval time: 0 second

paper: bad



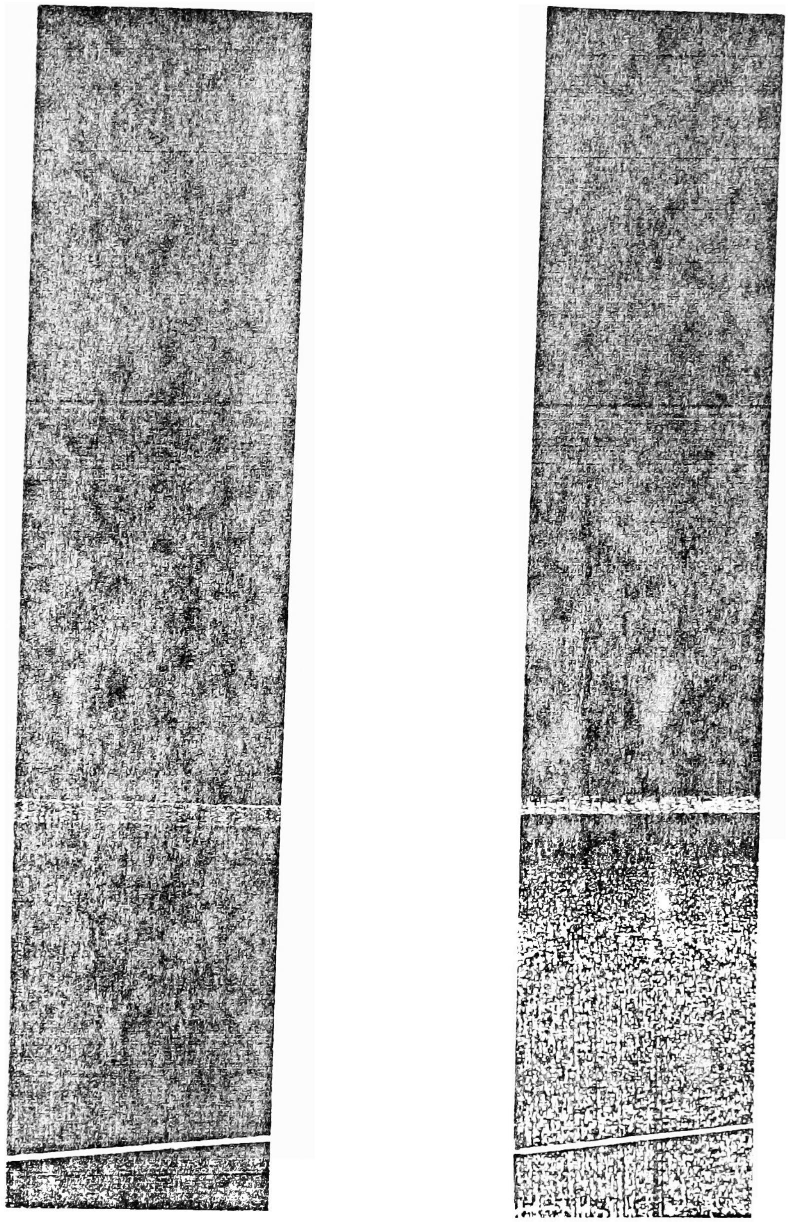
left: Disc A

right: Disc B

Figure B-11. wetting fluid: water

interval time: 0.3 second

paper: bad



left: Disc A right: Disc B

Figure B-12. wetting fluid: water

interval time: 0.6 second

paper: bad

Appendix C

Comparison of the influence of the interval times

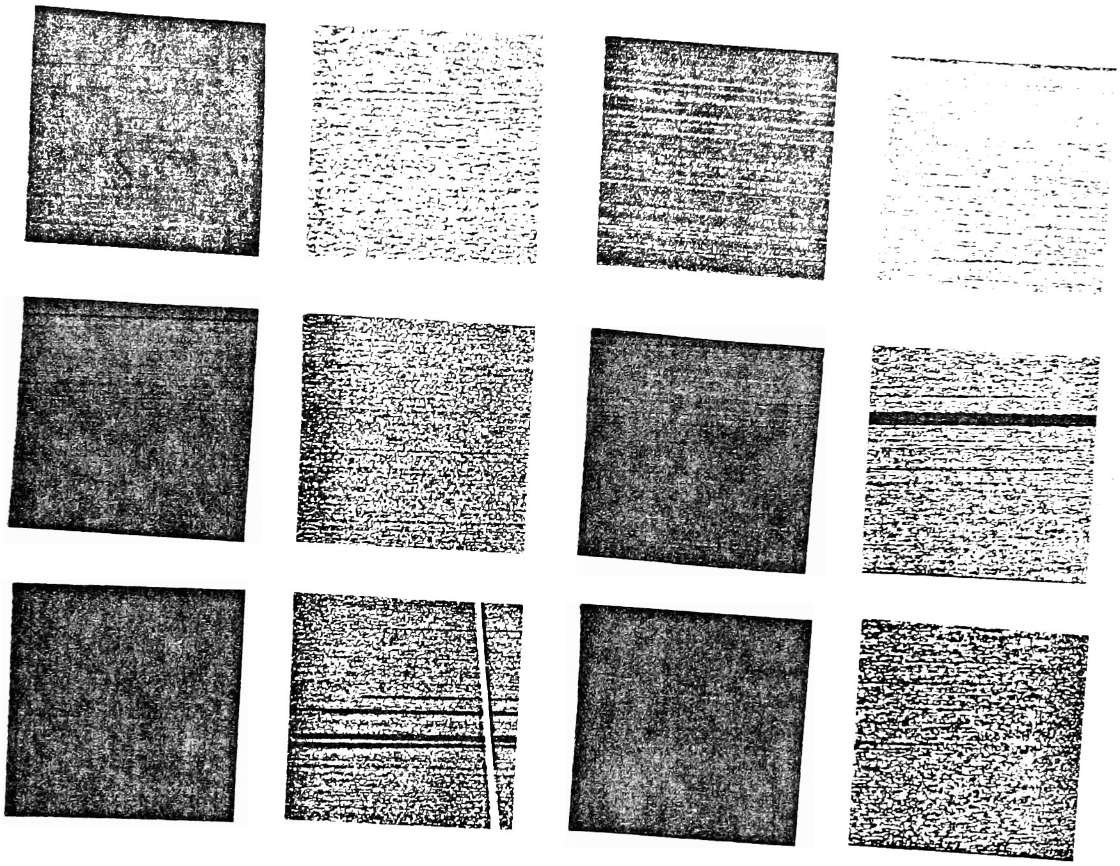


Figure C-1. paper: good

Top: interval time 0 second

Middle: interval time 0.3 second

Bottom: interval time 0.6 second

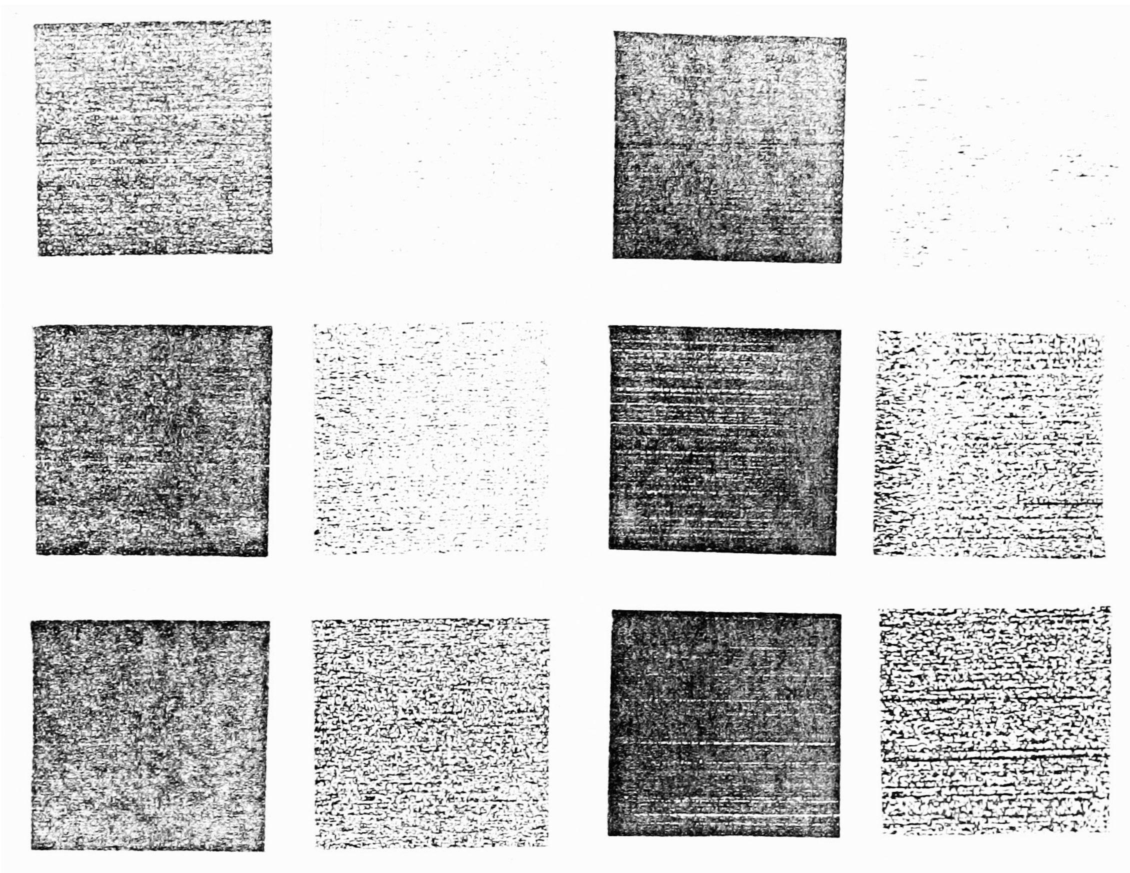


Figure C-2. paper: bad

Top: interval time 0 second

Middle: interval time 0.3 second

Bottom: interval time 0.6 second