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RELATION OF PAPER PROPERTIES TO REGISTER IN OFFSET LITHOGRAPHY

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ABSTRACT

Additional information has been obtained on the relation of fiber properties of paper to distortion and poor register in offset printing. Made-to-order papers, in the manufacture of which the fiber characteristics were carefully controlled, were tested in the laboratory and printed on a commercial offset press. Data on the closeness of register in printing were correlated with the properties of the papers and history of manufacture.

In previous studies of papers made in one mill of fibers from the same source, it was found that papers with a minimum of hydration or gelatinization of fibers and a maximum of directional difference or grain had the lowest machine direction expansion and gave best register. By the further tests on papers made in different mills of pulps from widely different sources, these findings were found to apply generally to chemical wood-fiber papers. With the chemical wood papers, best register is obtained when the machine direction coefficent of expansion is lowest. This desirable property is obtained by manufacturing the paper with the minimum of beating and jordanning essential for the required strength and surface quality. For all-rag papers, large directional difference or pronounced grain is apparently not indicative of low expansion and good register.

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I. INTRODUCTION

In previous study of the relation of paper properties to register of successive color prints in offset printing,[1] and on the influence of atmospheric changes on paper distortion,[2] the mechanical treatment of the paper fibers received in the manufacture of the paper was found to be of great importance. Paper made with a minimum of beating [3] and jordanning [4] gave best register in offset lithography. However, inasmuch as the papers used were from a single mill, and made of pulp from the same source, further studies reported herein were made to determine whether the conclusions based on the previous

[1] BS J.Research 9,427(1932); RP480.

[2] BS J.Research 12,53(1934); RP633.

[3] Beating is the term applied to mechanical treatment given papermaking fibers, suspended in water, to prepare them for forming a sheet on the paper machine. Beating separates, brushes, and frays the fibers, and causes them to absorb water by what is commonly termed "hydration".

[4] Jordanning is a refining process that usually follows beating to complete the preparation of papermaking fibers for forming a paper of the desired character. In the jordan, the fibers are freed from lumps and cut to the desired length.

findings relative to the relationship between fiber properties and distortion in offset printing are of general application. Special papers were prepared for this study by cooperating commercial manufacturers, and the experimental printings were made in the air-conditioned pressroom of the United States Coast and Geodetic Survey, Department of Commerce.

This is one of a series of studies made to assist the lithographers in reducing serious economic losses caused by difficulties in offset color printing. The work is being done in cooperation with the Lithographic Technical Foundation, which assists through an advisory committee composed of lithographers, paper manufacturers, and printing-equipment manufacturers appointed by the foundation.

II. DESCRIPTION AND PROPERTIES OF PAPERS

The papers used in the experiments were made according to the following specifications:

Group A.—Chemical wood offset papers made in mill "A". Fibers, 75 percent sulphite, 25 percent soda, wood pulp. Rosin sizing, 2.3 percent by weight. Finish, normal. Number 1 made with absolute minimum of beating and jordanning; no. 2 made from the same stock, with maximum of beating and jordanning commonly used in commercial practice.

Group B.—Nos. 3 and 4, duplicates of nos. 1 and 2, respectively, made in mill "B" of pulps from different sources than those used for group A papers.

Group C.—Nos. 5 and 6, duplicates of nos. 1 and 2, respectively, made in a third mill, "C", of pulps from different sources than those used in groups A and B.

Group D.—Nos. 7 and 8, 100-percent rag papers prepared like nos. 1 and 2, respectively.

Number 9.—A vegetable parchment paper. This type of paper is rendered parchment-like by gelatinizing the fibers with acid, which gives it properties somewhat comparable to a paper hydrated or gelatinized by drastic beating. It was included as being representative of the extreme as regards mechanical treatment of fibers. The test data on the papers are contained in table 1 on page 615.

The effects of increased beating on the physical properties of the papers may be observed from the data in the table by comparing the properties of the two papers in each group. The odd-numbered papers were made with minimum beating, and the even-numbered ones with the maximum. In general, increased beating decreased the machine direction [5] folding strength sharply with relatively little effect on the cross-direction strength; hence, maximum directional difference, or most pronounced grain, was associated with the minimum of beating and jordanning. The papers in group B might appear to offer an exception, but this is explained by the fact that these two papers actually differed little as regards fiber length, both having been jordanned rather hard. Apparently the difference between them may be attributed to hydration only, this being reflected also in the comparatively small difference in expansion. For all-chemical wood papers, the machine direction expan-

[5] Machine direction in paper is the direction parallel to its forward movement on the paper machine in manufacture. The direction at right angle to the machine direction is termed "cross-direction."

sion was lowest with both beating and jordanning at the minimum; a most important property since register in color printing requires a minimum of distortion in the machine direction of the paper.

Air permeability and rate of oil penetration were both greatly decreased by increased beating, indicating closing of the spaces between the fibers in the paper. The greater degree of curl with increased beating is further indication of this closing of the sheet. Beating had no significant effects on the degree of sizing or opacity.

III. REGISTER STUDIES

The special papers were subjected to experimental printings on a commercial offset press, and the closeness of register of color prints was determined for all papers by measuring with a micrometer rule.[6] The press was a 26- by 38-inch Harris offset model of late design in practically new condition. The cylinder dimensions of the press were:

	Plate	Blanket	Impression
	Inches	*Inches*	*Inches*
Bearers	16.000	16.002	15.976
Body	15.590	15.850	15.986

The press-room atmosphere was controlled with an air-conditioning system of conventional type. During the experiments, 43 ±4 percent relative humidity and 75 ±3° F were maintained.

In the first series of printings, five sheets of each paper were printed. The papers were conditioned in a cabinet type of conditioning machine in which room air is blown up through the chamber where the papers are hung. The sheets were hung in "lifts"[7] of two sheets each and left in the conditioning machine for approximately 24 hours to assure complete moisture equilibrium with the press-room air. Six-color printings were made, and the register was determined by measuring the length of each succeeding print on both back and gripper edges.

In these printing tests, the same printing pressures were used for all six colors. The pressure[8] between plate and blanket was equivalent to 0.004 inch. The impression cylinder was set up against the blanket cylinder with just sufficient pressure to give a clear print on the first color, and like pressure was used on all six colors. The register of successive prints in this series is shown graphically for the gripper and back edges of the paper in figures 1 and 2, respectively. Only the long-direction misregister is shown, because misregister in the short or around-the-cylinder direction is relatively unimportant, as it can be corrected by press adjustment.

[6] BS J.Research 9,431(1932); RP480.

[7] By "lift" is meant the number of sheets of paper placed together in the same clips suspending the paper from the top.

[8] On the type of offset press used, the plate cylinder and blanket cylinder rest one against the other on fixed metal bands or bearers at the ends of the cylinders. When the combined heights of the cylinder bodies between the bearers is not greater than the combined heights of the bearers, the pressure between plate and blanket is zero. Pressure is introduced by placing sheet packing under the blanket and plate to bring the combined body heights of the two cylinders above their combined bearer heights. There is no convenient method of determining the actual pressure, and since it is adjusted by increasing or decreasing the amount of packing, pressure is commonly expressed as being equivalent to the difference between the combined body heights and bearer heights.

It will be noted that, of the chemical wood papers, that is groups A, B, and C, the odd-numbered paper in each group gave better register than the corresponding even-numbered papers in the respective groups. The odd-numbered papers were those prepared with a minimum of beating and jordaning, and having in consequence, the most pronounced grain or directional difference in sheet formation. Paper 9, which was a parchment paper comparable in structure to a paper made with much more drastic mechanical treatment of fibers than any of the other papers, gave correspondingly greater misregister of prints. This further emphasizes the importance of sheet formation with respect to distortion and resulting misregister of prints.

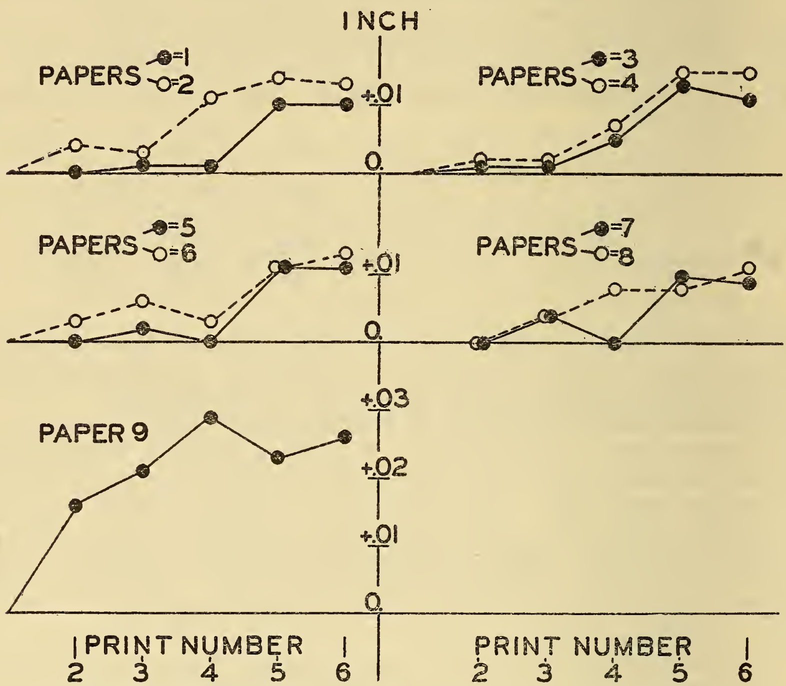

FIGURE 1.—*Relation of prints 2, 3, 4, 5, and 6 to first print length.*

Gripper edge—40-inch image.

NOTE.—Departure from 0 base equivalent to misregister with first color. Odd-numbered papers made with minimum of beating. Pressure on plate cylinder 0.004 inch for all colors.

There was no significant difference between the two rag papers in group D with respect to quality of register in these tests.

To obtain further data on these papers, a second series of printings was made under somewhat different conditions. In these tests, five sheets of each paper, with the exception of no. 9 which gave such poor register in the first printings as to require no further study, were printed. The papers were conditioned as for the first series, but were printed as part of a commercial run. The experimental papers were placed at the bottom of a pile of paper being printed on an airway map job, and were not removed for measuring until five colors had been printed. In these printings, the pressure on the plate cylinder was 0.0033 inch for each of the first two colors, and 0.0035, 0.0030, 0.0040 inch for the third, fourth, and fifth colors, respectively. Register of the fifth color with the first was determined.

As in previous tests with chemical wood papers, those made with the least drastic mechanical treatment of fibers, and having in conse-

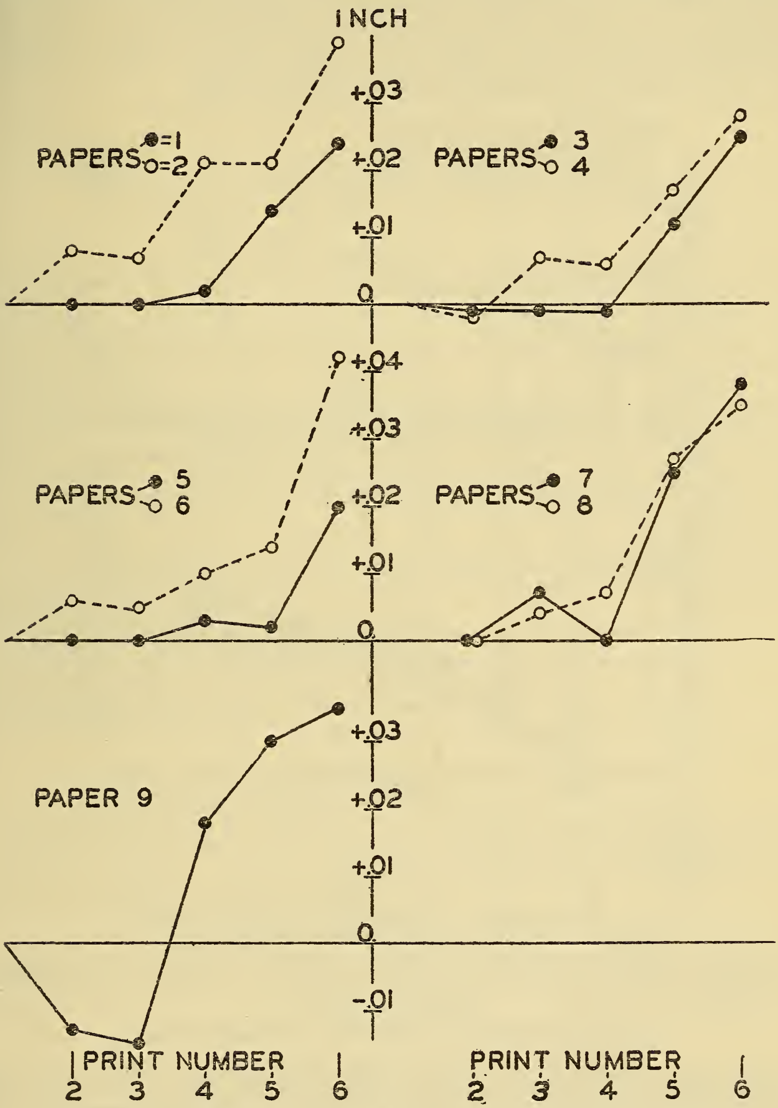

FIGURE 2.—*Relation of prints 2, 3, 4, 5, and 6 to first print length.*

Back edge—40-inch image.

NOTE.—Departure from 0 base equivalent to misregister with first color. Odd-numbered papers made with minimum of beating. Pressure on plate cylinder 0.004 inch for all colors.

quence, the lowest machine direction coefficient of linear expansion, gave the best register. The relationship between the coefficient of expansion and misregister of prints on the chemical wood papers is shown graphically in figure 3. Separate curves show relationship for this and the preceding series of printings and it is significant that similar regularity of the curves shows that misregister increased directly with the coefficient of expansion. The rate of increase, or slope of the curve, is not the same for the 2 different series of printings because many factors such as ink areas, amount of ink and water, printing pressures, etc., which have been found to affect register [9] are never duplicated exactly for different printings.

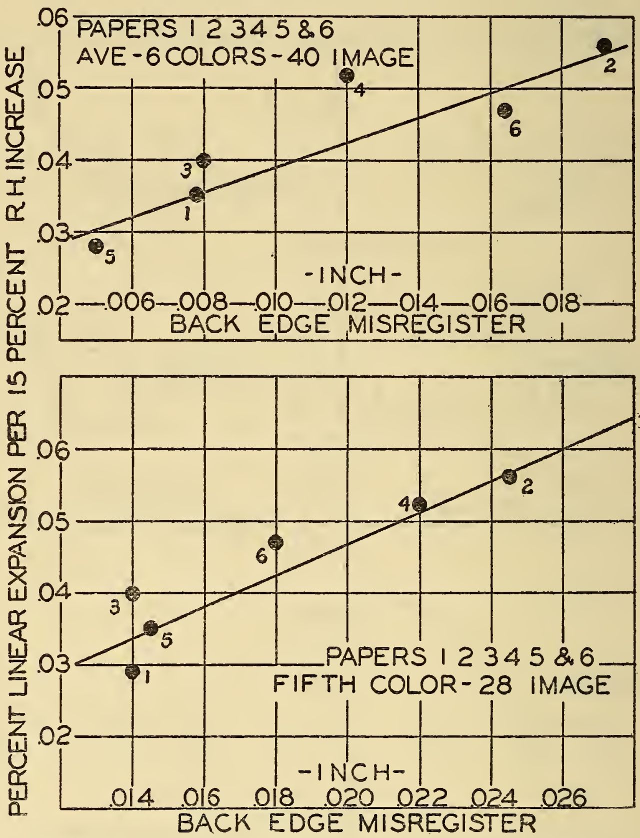

FIGURE 3.—*Relation of machine direction coefficient of expansion to misregister.*

Chemical wood papers.

NOTE.—Odd-numbered papers made with minimum beating.

Papers nos. 7 and 8, the all-rag papers made from the same stock with different degrees of beating, did not differ significantly with respect to register in either series of printings. Also, it will be noted in table 1 that while they differed as regards strength about as might be expected from the difference in mechanical treatment of the fibers, the machine direction expansion was practically the same for both. It appears, therefore, that the different manner in which rag papers respond to mechanical treatment makes the degree of beating and jordanning, so important in the case of wood fiber papers, of little

[9] BS J.Research 9,431(1932); RP480.

importance in rag papers with respect to the best sheet formation for low expansion and good register. The well known fact that cotton rag fibers fray out into threadlike fibrillas, and do not hydrate readily on beating, while the ordinary chemical wood fibers hydrate with very little fraying out, may give a clue to the reasons not clearly understood at present for the different behavior of the rag papers.

Table 1.—*Lithographic papers—test data* [1]

Properties	Test data on groups, and papers [2] nos.—								
	A		B		C		D		9
	1	2	3	4	5	6	7	8	
Weight (25 by 40 in., 500 sheets)...lb..	73.1	77.1	72.2	81.9	78.2	76.5	72.8	71.5	68.2
Thickness...in..	.0054	.0054	.0055	.0058	.0054	.0050	.0051	.0049	.0039
Bursting strength...points [9]..	26	21	22	27	31	35	26	21	45
Folding endurance [3]. machine..double folds..	52	8	11	19	480	153	71	28	5,860
Folding endurance [3]. cross...do....	10	5	7	10	35	89	20	10	8,720
Tensile breaking strength [4] machine...kg..	6.6	5.7	5.6	7.8	8.8	9.8	6.2	5.5	8.5
Tensile breaking strength [4] cross...do....	2.9	2.8	3.3	3.2	3.8	5.2	3.0	2.6	6.2
Degree sizing (dry indicator)....sec..	45	40	47	59	65	73	20	16	300+
Air permeability [5] .cm³/sec/m²/g/cm²..	149.2	69.0	253.9	107.5	468.0	86.5	196.0	98.9	.003−
Oil permeability [6] (castor oil)....sec..	150	240	103	240	65	266	123	139	7200+
Curl [7]...degrees..	50	65	28	48	11	23	45	65	180+
Expansion [8] per 15 percent R.H. increase (machine dir.)...percent..	.035	.056	.040	.052	.028	.047	.034	.038	.217
Opacity...do....	93	95	93	94	96	94	93	93	48
Ash...do....	7.7	11.3	8.0	10.0	5.8	8.6	8.7	9.7	0.2
Fiber composition chemical wood.do....	100	100	100	100	100	100	-------	-------	-------
Fiber composition rag...do....	-------	-------	-------	-------	-------	-------	100	100	-------

[1] All tests, except curl, expansion, air and oil permeability, made by the methods of the Technical Association of the Pulp and Paper Industry.
[2] Odd-numbered papers made with minimum of beating.
[3] For test specimen 15 mm wide and 90 mm between jaws.
[4] For test specimen 15 mm wide and 100 mm between jaws.
[5] Determined with Carson permeability tester. BS J.Research **12**, 567(1934); RP681.
[6] Resistance of printing papers. Tappi Assoc. Papers [XI], no. 1(1928).
[7] Determined with Carson curl tester. Paper Trade J. **79**, 48(1924).
[8] Test specimens 44 in. long.
[9] Bursting pressure in lb/in.² through a circular orifice 1.2 in. in diameter.

IV. SUMMARY AND CONCLUSIONS

The results of trial printings of three groups of special papers made in different mills, of different pulps, confirm previous findings, and justify the following general conclusions relative to chemical wood papers for multicolor offset printing:

1. Lowest machine direction coefficient of linear expansion of paper results in the most satisfactory register of successive color prints.

2. Machine direction expansion of paper is lowest when the greatest number of fibers are parallel to that direction, and the gelatinization of fibers, commonly termed hydration, is at the minimum.

3. The sheet formation with respect to fiber orientation and hydration can be controlled by proper control of the mechanical treatment of fibers in manufacture. Fiber length should be kept at the maximum and hydration at the minimum, by keeping both beating and jordanning at the minimum required for suitable strength and surface quality.

4. The desirable sheet formation is characterized by large directional difference, or grain effect, due to fiber orientation; therefore a high ratio of machine direction to cross direction folding endurance is generally indicative of good formation for close register.

The all-rag papers did not respond in the same manner as the much more widely used type, the chemical wood papers, with respect to the relation of sheet formation to machine direction linear expansion. Hence, control of the mechanical treatment of the fibers did not in itself control expansion. With the present knowledge, the only available method of predicting the register for rag papers is by determining the coefficient of expansion.

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