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Some Factors Which Influence the Rigidity and Durability of Waxed Paperboard Cartons for Packaging Liquid Food Products

R. Nitz

Western Michigan University

SOME FACTORS WHICH INFLUENCE THE RIGIDITY AND DURABILITY OF WAXED PAPERBOARD CARTONS FOR PACKAGING LIQUID FOOD PRODUCTS

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I INTRODUCTION

A. Paperboard

There are many types of heavy papers and paperboards manufactured today from various pulps. The paperboard which has grown the fastest in consumption in the past ten years is that intended for packaging foods. (1) The most common food board is that manufactured from southern pine woods, by the Kraft process. This board, manufactured on either a cylinder or fourdrinier machine, is nearly all consumed by manufacturers of varied milk cartons, and fruit juice cartons. These cartons are fabricated from the afore mentioned paperboard for many reasons.

The sourthern kraft paperboard, as it is called, has the greatest strength with the lowest weight and cost. The combination of this board and waxes makes a very economical package for both the dairy product producer and consumer. This is true, as the board has a lower cost than other competing materials. Waxes are used to impregnate the board due to their relatively low cost, excellent water and odor proofing and ease of application.

B. Problem

The problem of packaging liquid food products in waxed paperboard cartons is that of rigidity and durability. The carton must protect the contents from contamination and leakage, and must retain its rigidity for ease of handling.

There are many variables which will effect the rigidity and durability of the cartons. The intention of this study is to learn as much as possible from the available literature of these variables. From that learned it is hoped that some of the most important factors may be selected and studied further in the laboratory.

II VARIABLES OF THE PAPERBOARD AND WAXES AS LEARNED FROM THE AVAILABLE LITERATURE

A. Paperboard variables

1. Stiffness

a. Defining stiffness

Stiffness of the paperboard is a function of the stress - strain relationships. Paperboard is not an ideal elastic solid. Therefore, it exhibits time dependent flow properties.(1) This means that the stress developed in producing a particular strain will vary with the time involved in producing the strain. Stiffness is related to the flow properties because it depends upon the outside curve of the material to stretch and the inside of the curveto undergo compression.(2)

Moisture content changes the stress - strength relationships of paperboard as water is a plasticizer for the cellulose of the fibers. Increased moisture content increases the flow properties in that it increases the rate of stress relaxation. Stress relaxation is also called creep; creep is divided into two categories, namely primary and secondary. Primary creep is the recovering of its initial shape, whereas secondary creep is non-recoverable, resulting in some permanent set.(2)

b. Measuring stiffness

Stiffness may be measured in our laboratory by three different methods: by the Gurley stiffness tester, the Taber stiffness tester, and by adapting the standard tensile tester. These will be briefly discussed in respective order.

Taber instrument measures the immediate deformation resistance and also the time dependent flow properties.(3)

Gurley instrument measures the immediate deformation only. (3)

The regular tensile tester may also be used with a special device which permits the application of the load at the center of a strip of the board held at both ends. Results can be reported in load at failure, or maximum load. The deflection in inches also is measured. (2)

In studies by the Institute of Paper Chemistry a formula was used to determine the stiffness of the paperboard. The formula used did not take into account the time element (2) or the plasticizing effect of water upon the cellulose.

The waxed carton is subjected to flexural deformation over a prolonged period of time. If the wax coating is not impervious to water and allows some of the package's contents to seep into the board, then the cellulose will be plasticized which will increase the plastic flow properties of the board.

From the above data, it would seem that a test should be used which would take these factors into consideration.

2. Sizing

a. Purpose of sizing

Internal sizing with rosin or rosin-wax combinations.

The purpose of sizing is to aid or alter the natural characteristics of cellulose fibers. Sizing with rosin or rosin-wax combinations aids in making the fibers water repellent, and starch sizes tend to make the fibers oil and grease repellent.

b. Methods of sizing

Sizing of paperboard is accomplished by two principle means: internal and external sizing.

Internal sizing may be accomplished with rosin size, combinations of rosin and wax, or with starches.(5) Internal sizing is the addition of the sizing agents at some point in the stock system, preceeding the headbox. Generally the sizing agent is added to the beaters, refiners, or at the fan pumps in the system.

External sizing (surface sizing) is the addition of the sizing agents to the surface to the paperboard after it has been formed, pressed, and nearly dried. The size may be applied with a size press and redried, or it may be applied at the calender stacks from a waterbox.

For a thorough discussion of the fundamentals and theory of sizing the reader is referred to J. P. Casey's Pulp and Paper, vol. I (4) or to Tappi text, Vol I (5).

c. Variables of Sizing

Internal sizing with rosin or rosin-wax sizes has the twofold effect of increasing the angle of contact between the fiber and water and making a zero angle of contact between the fibers and waxes.(2) Rosin size tends to increase the strength properties of the board and increase the absorption of waxes over that of an unsized sheet. However, rosin-wax combinations decrease the strength properties, but increase the wax absorption over that of rosin sizing alone.(6)

It has been found that the degree of beating has a decided effect upon the sizing efficiency of rosin sizes. In a study by Wilson(7) it was found that very lightly refined pulps retained a greater percent of rosin size than more highly refined pulps. In another study by Wilson it was learned that rosin sizes almost completely water proof the exterior surfaces, but it apparently does not have any effect on the water absorbing characteristics of the interior of the fibers.(8)

Starch is used in internal sizing to aid the stiffness of the board, and in the case of cylinder board it aids in the lamination of the plies.(4)(5)

External sizing of paperboard generally is accomplished with starches. Other materials used for surface sizing are: carboxymethylcellulose, methyl cellulose, and Poly-vinyl-alcohol. All of these surface sizing agents tend to increase the angle of contact between the fibers and the waxes.(4) These agents are used as controls to prevent the wax consumption of the cartons from becoming too great and also to help lay down the surface fibers to prevent wicking after waxing. (8) It also has been found that if the

quantity of starch is too great then a poor wax coating will result as the starch will not allow enough wax absorption (9) (10)

3. Calendering

Calendering the paperboard is a means of regulating the density, porosity caliper, and smoothness of the paperboard. The caliper is very important from the standpoint of converting as the caliper must be uniform for trouble free operations. Porosity is an inverse function of density in that if the density is increased the porosity is decreased, and the wax consumption is decreased. The density also plays a role in the stiffness of the paperboard, that is the more dense the board the stiffer the board will be.(2)

Smoothness is a very important factor for good waxing. If the board is too smooth, then the surface fibers are too tightly knit together, and this will decrease the wax absorption, and also cause trouble in the converting operations. If the paperboard is not smooth enough and the surface fibers are quite loose, then after waxing some of the fibers may stick through the wax coating and act as wicks to absorb the contents of the carton(9).

B. Waxes and Waxing Method Variables

1. Waxes

The waxes used for carton waxing are those derived from petroleum. The petroleum waxes are divided into two broad categories: paraffin and microcrystalline waxes.

Paraffin waxes are separated from crude petroleum by fractional distillation. This wax has large, well-defined crystals of the plate and needle type. The melting point range of paraffin is between 125°F and 150°F. Paraffin is quite hard and brittle when cooled, and has somewhat low adhesive ability.(11) Its principle advantage is its low cost and very light color.

Microcrystalline waxes are subdivided into three classes which are: motor oil wax, residual, and tank bottom.(11)

Motor oil wax is removed from the motor oil fraction of crude petroleum by solvent extraction. Residual waxes are removed from the fraction, which is heavier than the motor oil, by solvent extraction also. The tank bottom micrycrystallines separate from the heaviest fraction of petroleum upon cooling.(11)

The microcrystalline wax used for waxing the previously mentioned cartons is that derived from motor oil because it is the lightest in color. This wax ranges in structure from amorphous to extremely small and indistinct crystals. This is a very desirable wax as it has a higher melting point range, (135°F - 155°F), high tensile strength, high adhesive ability, is very flexible and retains its flexibility at lower temperatures. The big disadvantage is its high cost in relation to paraffin.

Thewax most commonly used is paraffin modified with 2% to 10% microcrystalline waxes. The small amount of microcrystalline tends to retard crystal formation and improve the adhesive ability, and flexibility of paraffin. This was shown in a study by Kreyenbuhl.(12) In this study

papers of the same stock were waxed with pure paraffin, pure microcrystalline and blends of the two. Microcrystalline and blends showed slightly less resistance to water vapor transmission than paraffin, but on folding the waxed stocks, the microcrystalline lost much less of its water vapor resistance than paraffin.

Paraffin wax is also modified with polyisobutylene and polyethylene to achieve the same results. These, however, are somewhat higher in cost.(11)

2. Waxing Methods

Wax may be applied to paperboard by any of the conventional coating methods. The board may be dipped, sprayed, or wax applied with a Mayer waxer. In any case, the waxing is categorized by the way the wax is on or in the board. If the wax is in the stock, but not on the surface, then it is classified as dry waxed. If the wax is on the surface, with any degree of penetration, it is classified as wet waxed.(13)

Cartons for liquid foods are always waxed after fabrication by the immersion method, and are quite well penetrated and wet waxed.

Some of the variables of the waxing process itself are: the penetration time, the temperatures of the carton, and wax bath.

If the carton is not immersed for a long enough period, then it will not be thoroughly impregnated. If the carton temperature is considerably below that of the wax bath, then the wax will conged on the surface and not penetrate. Finally if the wax temperature is too high, too much wax will drain from the surface, and dry waxing will be experienced.(14)

III FACTORS SELECTED

From the knowledge gained from the literature, it is shown that the surface sizing is one of the most troublesome variables, along with differences of moisture content. It is felt then, that these should be the factors given a more comprehensive study;

END

BIBLIOGRAPHY

1. Evans, John C. W., Where Does Your Grade Stand? Paper Trade Journal 139, no. 46: 34-37 (Nov. 14, 1955)

2. Casey, J. P. Pulp and Paper Chemistry and Technology Vol. II Interscience Publishers, Inc., New York 1952

3. Institute of Paper Chemistry, Instrumentation Studies, Paper Trade J. 104, No. 21: 287-290 (May 27, 1937)

4. Casey, J. P. Pulp and Paper Chemistry and Chemical Technology Vol. I Interscience Publishers, Inc., New York 1952

5. Pulp and Paper Manufacture Vol. 2 Joint Textbook Committee of The Paper Industry of the United States and Canada McGraw-Hill Book Company, Inc. New York 1951

6. Griesinger, W. K., and Reynolds, M.H. Paraffin Waxes - their application to papermaking Paper Industry 22 no. 3: 248-251 (June 1940); B.I.P.C.10:428; C.A. 34:6070

7. Wilson, William S. Mechanism of Water Resistance - the effect of beating Tappi 32, no. 9: 429-432 (Sept., 1949); B.I.P.C. 20:108; C.A. 43:9441; Tech. Bull. 26:57

8. Wilson, William S. Why Size Paper? Paper Mill News 72, no. 21:80-82 (May 21, 1949); Paper Industry 20, no. 10:1514, 1516, 1518, 1520, 1522 (Jan., 1949); B.I.P.C. 19:716; B.A. 1949 B, II 623

9. Rauscher, Norman L. Waxed Paper Tappi 35, no. 2:94-95A (Feb., 1952); B.I.P.C. 22:513

10. Faults in Waxed Carton Containers. Patra J. 3, no. 2: 58-59 (Sept., 1939); Paper Container 42, no. 1:17, 19 (Jan. 1, 1940); B.I.P.C. 10:361.

11. Kirk, R.E. and Othmer, D. F. Encyclopedia of Chemical Technology Vol. 10 Intersicence Publishers, Inc. New York 1953

12. Kreyenbuhl, A. Study on the (Water-Vapor) Permeability of Paraffin Papers. Bull. Assoc. Tech. Ind. Papetiere 5, no. 5:257-263; discussion, 263-264 (July, 1951); B.I.P.C. 22:38; C.A. 45:8768

13. Caine, Robert D. Waxed Papers Western Michigan College Industrial Lectures on Paper and Paperboard Converting, The Lockwood Trade Journal Company, Inc. New York 1954

Bibliography Continued

14. Techniques of Carton Waxing, Boxboard Containers 70, no. 709: 17-18, 20 (Jan., 1952); B.I.P.C. 22:395.

Experimental Outline
Robert H. Nitz
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I OBJECTIVE

The object of this work is to study one of the variables affecting the rigidity and durability of waxed paperboard cartons, intended for packaging dairy and other food products.

From the literature survey it was learned that there were many factors which affect the stiffness of the paperboard. The initial paperboard stiffness is the determining factor of final carton rigidity.

To narrow the field of study, it is assumed that if the initial stiffness, tensile and bursting strength of the paperboard is sufficient, then the final waxed carton should be rigid and strong enough for its purpose. This will be true only if moisture from the packages' contents do not contact the paperboard and plasticize the cellulose of the fibers.

The purpose of the wax coating is to prevent moisture from coming into contact with the paperboard, but not all paperboards with similar initial physical characteristics have the same carton durability. It is felt that in these cases the paperboard did not have as good of a wax coating as other boards, the evidience being higher moisture absorption. This was learned by experience working at the International Paper Company, Single Service Division Quality Control Laboratory in Kalamazoo, Michigan.

From the literature survey it was learned that the condition of the paperboard surfaces play a part in the waxing. Therefore, the variable which will be studied is that of surface smoothness.

II PROCEDURE

A. General Method

A sample of paperboard has been selected which has a very low density and a natural surface finish, that is, the board has not been surface sized or calendered. This paperboard will be used as a base stock with which to vary the surface smoothness by calendering alone, and by surface sizing first then calendering. In subsequent tests, this should show whether surface size plays any major role in the waxing of the paperboard. This board will hereafter be called the "base stock" in this paper.

B. Specific Method

The performance of the base stock as is, has been determined in the Quality Control Laboratory of International Paper Company, Single Service Division by the lactic acid test. This lactic acid test is simply a matter of filling the waxed carton with a one percent lactic acid solution and allowing it to stand at room temperature for seventy-two hours. The degree of swelling and acid absorption are the criteria of carton durability. This test was found to correlate well with the durability of the carton under actual usage, by Excello

Corporation. For any further information on this test, Mr. D. J. Crawford of Pure Pak Laboratories, Excello Corporation, Detroit, Michigan, may be contacted, as there are doubts whether this test was ever actually published.

It is proposed then to starch size samples of the base stock with as high of a solids content starch solution as possible with a Mayer coating rod, and air drying. By doing it this way it is hoped only the surface will be sized with a minimum of penetration.

The starch sized base stock samples will then be calendered along with unsized samples to the same degreeof smoothness, as determined by the Bekk smoothness tester. The smoothness will be varied all the way from a very low degree to a very high degree.

Each degree of smoothness of the base stock will be given the following physical tests: Bekk smoothness, burst, caliper, and Gurley stiffness.

The samples will then be waxed by hand dipping for ten seconds in a wax bath at a temperature of 170° - 180°F. Again the aforementioned physical tests shall be applied.

The waxed samples will then be soaked in one percent lactic acid solution for seventy-two hours, and the above physical tests will again be applied. In addition the acid absorption will be determined and

another test will be applied to determine the quality of the wax coating. This test will be conducted by placing a portion of the wax sample in an open ring lid of a common Mason jar and screwing the lid thus formed on to the jar. The jar bottom will have been removed previously, therefore allowing the jar to be placed with the ring lid downward and permit filling the jar with an alcohol-dye solution, for a certain period of time, then emptying, remove sample and examine for surface defects of waxing, which will be shown up by the alcohol dye penetration.

If the foregoing method does show a detrimental effect of surface smoothness upon the wax coating quality of the paperboard, then samples of paperboard will be selected at International Paper Company, Single Service Division, which have a highdegreeof surface smoothness. This board will be converted and the cartons subjected to the standard tests at International Paper Company and the samples will also be hand waxed and tested in the same manner as the "base stock."

III TIME BUDGET

A. Laboratory Periods

There are fifteen Mondays left in which to do the laboratory work. The first three periods will be spent assembling materials and preparing the base stock for subsequent operations.

B. Make-up Time

I have been allowed the time off, between 1:00 P.M. and 2:30 P.M. on Mondays to attend another class. This time shall be made up on Friday mornings between 11:00 A.M. and 12:30 P.M. when the samples shall be cut and placed in the lactic acid, for the proposed seventy-two hours.

IV APPARATUS AND MATERIALS

1. Wax tank - empty five gallon ink pail.
2. Lactic acid tank - empty five gallon ink.
3. Thermostatically controlled hot plate.
4. Thermometer (either centigrade or Fahrenheit).
5. Mason jars (quantity to be determined).
6. Mayer Coating Rod*
7. Mayer suction plate for hand coating.
8. Gurley stiffness tester.
9. Mullen burst tester.
10. Super Calender Machine.
11. Concentrated Lactic acid.*
12. Wax similar to that in commercial use.*
13. Alcohol (denatured)*
14. Alcohol solution dye.

* These items are on inventory of International Paper Company Single Service Division Laboratory and may be drawn upon, free gratis.

ABSTRACT

It was found that a complete saturation of paperboard cartons is not desirable due to economics, but a surface film only of paraffin is wanted. Rosin size plays a very important role in the durability of the carton, as a good internal water resistance is necessary to protect the carton in event of paraffin film rupture.

I Introduction

A. Samples

A series of nine boards were selected for study. At the beginning of the semester results of end use tests were known on two samples. The two known samples are standard boards, against which all others are compared.

The end use test results of the remaining seven boards were not known until all laboratory work was completed. Theonly information given on these boards, is that they were all within the specifications, as far as strength, basis weight, caliper, porosity, wax absorption, etc., are concerned. See Table 1. in appendix.

B. Testing

From the literature survey it was learned that certain types of surface coatings, such as starch and gums, inhibit oil and melted paraffin penetration. As indicated in the experimental outline, this was the direction in which this study was to follow.

The nine samples were all dip waxed in melted paraffin ($172^{o}F$) for ten seconds and cooled at room temperature. The two standard boards acquired fairly uniform wax coatings, whereas the unknown seven boards exhibited varying degrees of mottling. Samples of these are included in the appendix, Table 2. The mottling was thought to be caused by either internal density conditions or surface blocking effects.

The samples were then subjected to a few tests to determine in which direction to continue the study. The results of these tests

indicated that the mottling effect was not as important as originally thought. It is shown, however, that a good internal water-resistance is essential for carton durability in use.

II Experimental Laboratory Work

A. Mottling Study

1. Internal Density

As an indication of differences of internal densities of the various boards, the fiber length classification was used. (Tappi method T 233sm-53).

The fiber length classification showed that some of the unknown boards did have higher internal densities than the standard boards. This was indicated by the amount of fines. (Table 3. in appendix.)

2. Surface Blocking

The procedure for studying surface film effects on paraffin penetration, as given in the Experimental Outline, was still going to be followed at this point.

It was felt that a few basic laboratory tests should be established, prior to the work indicated in the Experimental Outline, which might be used to correlate the unknown samples, to laboratory prepared samples.

The tests which came into mind at the time, were based upon penetration times of hot paraffin (172^{o}F), and weighed wax pick up over various time intervals. The effectiveness of various degrees

of wax penetration were going to be determined by soaking the samples in one percent lactic acid for 72 hours, and weigh absorption.

These tests showed only one thing, quite by accident, that complete wax penetration is not really desired, as originally thought. At this point it was determined that complete saturation of even the standard boards, would increase the wax consumption to the point that the board could no longer be competitive. Therefore, no further work in this direction was performed.

The conclusions at this point are: a surface film of paraffin only is desirable andthat a good water resistance of the board is necessary, in event of paraffin film rupture.

B. Water Resistance Study

1. Testing Method

The Cobb size test was used to determine water resistance. (Tappi method T 441 m-45)

A short period of time (5 minutes) proved to be the most effective for showing differences in water resistance, as the longer period of time tended to equalize all of the boards. See Table 4 in appendix.

2. Type of Sizing

It was noted while defibering the boards for the fiber length classification, with caustic soda, that the unknowns seemed to resist penetration longer that the standards.

Rosin size is quite readily soluble in hot one percent caustic soda, and would allow a ready penetration during defibering. It was thought that possibly some other sizing agent may have been used, such as a wax size.

To determine if paraffin wasused as a sizing agent, the Dunlop test was used. The results and description of this test is found in Table 5 in the appendix.

3. Water Resistance Tests

The five minute Cobb test was performed on samples, the results indicated that the boards did vary, but not to a huge degree. See Table 6 appendix.

4. Differention Between Surface and Internal Water Resistance

To establish if any difference existed between the surface water resistance and internal water resistance, the following method was used: The five minute Cobb test was performed on the samples with the surfaces both intact and removed. The surfaces were removed by peeling with pressure sensitive tape. The results are in Table 6 appendix.

The questions which arise from the preceeding work are: Is it a matter of not enough size, or isit the type of size used.

5. Determination of Most Effective Sizing Method.

It is desired to determine if one type of size is better than another, or if the quantity of size is a determining factor.

To determine if the quantity of rosin size is the determining factor, one of the standard boards was selected for study. This board did not contain internal paraffin size (as determined by the Dunlop test), but was a surface sized with paraffin. Alternate cartons made from this board were soaked for three hours in anhydrous isopropyl alcohol to remove rosin size, but leave any paraffin size on the surface, and dried. An equal number of the untouched cartons were then intermixed with the alcohol soaked cartons. The whole group was then formed and waxed on the converting machine. The cartons were then subjected to the 72 hour lactic acid test, described in the Experimental Outline. The results indicated that removing a small portion of rosin size, decreased the durability of the board. See Table 7 appendix.

III Conclusions

A. A surface film of wax is the most desirable, rather than complete saturation.

B. Although surface of board was sized with paraffin, the quantity of internal rosin size is determinant of board durability.

IV Recommendations

It is recommended that further study be made to determine if an internal sizing with a paraffin wax would be as effective as rosin size.

TABLE I.

Comparison of study samples to specifications

	Fourdrinier Specifications	1.(Std.)	2(Std.)	3.	4.	5.	6.	7.	8.	9.
Caliper (In.001 inches)	.016 ± .001	.0161	.0160	.0160	.0159	.0154	.0161	.016	.016	.0161
Basis Weight (#/3000 sq.ft.)	210# ± 9#	214#	216#	216#	204#	212#	223#	219#	214#	212
Mullen (#/sq.in.)	110# ± 20#	115#	117#	100#	102#	100#	125#	110#	105#	112#
Densometer (Sec./sq.in. per 100cc)fair	220 ± 30	164	212	206	141	199	210	174	241	187
Stiffness (Taber Units) Machine Direction	200 ± 40	210	225	180	185	205	220	203	206	190
Cross Machine Direction	80 ± 20	85	92	78	80	87	92	87	82	72
Tensile Strength (lbs./inch) Machine Direction	85# ± 20#	95#	92#	80#	79#	90#	96#	89#	90#	83#
Cross Machine Direction	60# ± 10#	60#	65#	55#	55#	63#	70#	63#	64#	58#
Paraffin Consumption (#1000 Containers)	37# ± 3#	38.4#	36.4#	34.8#	35.4#	35.5#	38.4#	35.6#	36.0#	36.4#
Lactic Acid Absorption (#1000 Containers) Waxed Container at 70°F	6.5# or less	5.8#	6.0#	7.0#	6.3#	6.6#	12.0#	14.6#	8.6#	7.2#
Bulge (from original 2-7/8") 32nds of an inch at 70°F	10 allowable	8.8	9.8	12.0	13.2	11.8	13.3	18.2	13.0	11.4

Table 2.

Showing the various degrees of mottling.

TABLE 3.

Fiber Length Classification

Sample	Screens				
	20 mesh	28 mesh	48 mesh	100 mesh	Fines
1. (Std.)	5.9 gm..	0.8 gm.	1.3 gm.	0.3 gm.	1.7 gm.
2. (Std.)	5.7 gm.	0.8 gm.	1.35 gm.	0.3 gm.	1.85 gm.
3.	5.3 gm.	0.89 gm.	1.6 gm.	0.5 gm.	1.7 gm.
4.	5.3 gm.	0.6 gm.	1.45 gm.	0.5 gm.	2.15 gm.
5.	4.85 gm.	0.7 gm.	1.4 gm.	0.45 gm.	2.6 gm.
6.	4.75 gm.	0.4 gm.	0.95 gm.	0.3 gm.	3.6 gm.
7.	5.2 gm.	0.8 gm.	1.65 gm.	0.5 gm.	1.85 gm.
8.	4.2 gm.	0.7 gm.	1.5 gm.	0.4 gm.	3.2 gm.
9.	5.3 gm.	0.75 gm.	1.4 gm.	0.6 gm.	1.95 gm.

Note: to obtain percentage, multiply reading by ten.

TABLE 4

Comparison of Cobb tests performed at short periods of time versus long periods.

	Percent by weight absorbed in time indicated	
Sample	5 minute	60 minute
1. (Std.)	6.37	22.2
2. (Std.)	5.35	26.8
3.	11.3	24.5
4.	10.0	27.7
5.	9.8	12.2
6.	7.29	13.0
7.	10.9	22.0
8.	9.1	27.8
9.	9.8	29.3

Note: The Cobb test is reported in percentage here as two different sizes of samples were used. The 60 minute test was performed by placing sample in a standard Mason jar lid ring and fastening to inverted jar.

TABLE 5.

Tests for Paraffin Size in Board by Dunlop* Test

Sample	Test Result
1. (Std.)	Positive
2. (Std.)	Positive
3.	Positive
4.	Positive
5.	Positive
6.	Positive
7.	Positive
8.	Negative
9.	Positive

* The Dunlop test is performed by boiling a sample in conc. acetic anhydride, filtering while hot and chilling. If paraffin is present, it will precipitate out as a white floc.

TABLE 6.

The five minute Cobb test performed on the samples with surface both intact and removed. Reported in grams of water absorbed per square meter.

Sample	Surface Intact	Surface Removed
1. (Std.)	35 gms./m^2	32 gms./^{2}
2. (Std.)	35 "	37 "
3.	60 "	67 "
4.	50 "	55 "
5.	50 "	56 "
6.	40 "	60 "
7.	60 "	82 "
8.	50 "	58 "
9.	50 "	60 "

TABLE 7

Comparison of alcohol soaked and untouched cartons made from the same board. See text for explanation.

Sample	Cobb test	Caliper	Porosity	Wax Absorption #/1000 cartons	Lactic Acid Absorption #/1000 cartons	Bulge 32nds of an in. over 2 7/8"
Untouched	38 gms./m^2	.01604	208	36.2#	5.6#	9.9
Alcohol soaked	47 gms./m^2	.0160	186	36.6#	6.2#	11.2