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A STUDY OF CASE-LINING PAPERS FOR THE PURPOSE OF DEVELOPING STANDARD SPECIFICATIONS

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A STUDY OF CASE-LINING PAPERS FOR THE PURPOSE OF DEVELOPING STANDARD SPECIFICATIONS

By B. W. Scribner and F. T. Carson

ABSTRACT

This paper gives the results of a study made for the purpose of developing specifications for waterproofed paper suitable for lining shipping cases intended for overseas transportation. The main requirements of paper used for this purpose are waterproofness and strength.

The type of paper found to give the most satisfactory service consists of two sheets of kraft paper cemented together with a layer of asphaltum which is the waterproofing medium. The test commonly employed for determining the water resistance of such paper was found to be inadequate. This method consists in placing the sample under a water column and noting evidence of transuded moisture by observation of the under surface which is exposed to the air. Papers having comparatively slight water resistance withstand this test indefinitely for the reason that the moisture evaporates as fast as it is transmitted through the paper, giving no visible evidence of its presence. A sensitive but positive method was evolved, whereby a ground-glass surface is used to trap and make visible transuded moisture. The combined bursting strength of the two basic kraft sheets of waterproofed case-lining paper has formerly been considered as a sufficient strength requirement. Tests of case-lining papers compared with tests of the basic kraft sheets showed that the layer of asphaltum lends an appreciable amount of strength. For this reason a bursting-strength requirement higher than that of the combined strength of the two basic kraft sheets is recommended to insure the use of kraft paper of the best quality.

The specifications recommended are: Weight, 109 pounds per 500 sheets, 25 by 40 inches in size; water resistance by the ground-glass method, not less than 24 hours; bursting strength, 70 points.

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I. INTRODUCTION

1. PURPOSE OF TESTS

At the request of the Bureau of Foreign and Domestic Commerce a study was made of waterproofed papers used for shipping purposes. Specific recommendations as to the kind of paper best suited for lining shipping cases were desired for the purpose of including such information in a publication dealing with the packing of goods for foreign markets.

2. CONSIDERATIONS INVOLVED IN SELECTION OF CASE-LINING PAPER

Overseas shipments are subjected to extremes of moisture conditions, and most commodities are injured more or less by water. The selection of paper to meet the demands made of it in such usage is of much importance, as considerable loss in damaged goods may result from use of paper not suited to the purpose.

The demands made on paper used for this purpose are most exacting. There are sudden and great changes in atmospheric conditions, and frequent handling of the shipping cases, often under the most adverse circumstances. The strength of paper is appreciably decreased by overheating or overdrying and even more so by wetting with water. Although the paper is used as a waterproofing medium, and therefore must be very water resistant, a high degree of strength which will keep it intact through all the sudden strains and shocks incident to transportation is a property of equal importance to its water resistance.

II. PRELIMINARY TESTS

1. SCOPE OF PRELIMINARY TESTS

With the assistance of the Bureau of Foreign and Domestic Commerce samples representing different types of waterproofed wrapping papers were secured for study from both domestic and foreign sources. Forty-four samples were included in this study. These papers were waterproofed in various ways and were of many types of structure, some being reinforced by textile materials. They were subjected to strength tests, and studies were made in respect to their resistance to permeation of water and the effect of extremes of temperature.

2. RESULTS OF PRELIMINARY TESTS

These tests showed that existing methods of determining the degree of water resistance of such papers were entirely inadequate. Fairly satisfactory results were obtained, however, with a modified form of the sizing test proposed by Stöckigt. This is described in the dis-

cussion of testing water resistance given below. The results of the tests, together with service records of these papers, also showed that as regards both strength and water resistance the type of paper known as "duplex asphaltum waterproofed" is best suited for the purpose. This type of paper usually consists of two sheets of 30-pound kraft paper cemented together with a layer of asphaltum which is the waterproofing medium. Kraft paper is strong enough for the purpose without reinforcement with cords or cloth backing, and the layer of asphaltum renders it practically waterproof when properly applied. As a result of this preliminary investigation, tentative specifications for waterproof case-lining papers were prepared for the Bureau of Foreign and Domestic Commerce and were published in its manual Packing for Foreign Markets.[1]

In order to develop a more satisfactory water-resistance test and to determine more definitely the strength requirement, the experimental work was continued. Only the duplex type of paper described above was considered in this further work. The products of nine different domestic mills were used for this study. Development of an entirely adequate and yet simple method of determining water resistance and establishment of a definite strength requirement resulted. A detailed account of this experimental work and the findings follow.

III. RESISTANCE TO PERMEATION OF WATER

1. LIMITATIONS OF EXISTING METHODS OF TEST

The customary method of testing paper for water resistance prior to this investigation consisted in subjecting the paper to a small head of water (usually by clamping the paper to the lower end of a cylinder and partially filling the cylinder with water) and noting the time until water was seen to penetrate through the paper as evidenced by the appearance of drops or by the paper's feeling wet to the touch. This method was found to be very misleading, owing to the fact that water may evaporate as fast as it comes through, especially in an atmosphere of low relative humidity, and hence escape detection. Heavy, hard-sized kraft wrapping paper when tested by this method appears to be waterproof, but when tested by the method finally adopted is found to allow water to pass through within a few minutes after being applied to one surface.

Other methods have been used which employ a weighed amount of some hygroscopic material in a closed space having an aperture closed with a specimen of the paper to be tested. On applying water to the outer surface of the specimen any moisture

[1] Packing for Foreign Markets, by John F. Keeley, transportation division, Bureau of Foreign and Domestic Commerce (Government Printing Office, Washington, D. C., 1924).

transmitted through is absorbed by the hygroscopic material which is reweighed at intervals. The rate of gain in weight of the hygroscopic material is a measure of the relative water resistance of the paper. Such methods are too involved and tedious for routine testing. It is felt that a method suitable for inclusion in specifications should be both sensitive and simple of operation.

2. DEVELOPMENT OF A MORE SUITABLE METHOD

The sizing test proposed by Stöckigt [2] in a slightly modified form was first used in the attempt to find a better test for water resistance than the existing methods. Specimens were floated on a solution of ammonium thiocyanate and drops of ferric chloride were placed at several points over the upper surface of the specimen. The time required for the two solutions to meet and produce the characteristic red color gave a much better indication of relative water resistance than that given by the customary water-column test. The Stöckigt test, although used in the tentative specifications, was not considered entirely satisfactory. In the case of highly ligneous paper the ferric chloride is reduced so that no color develops when the two solutions meet. Special solutions are required, a feature which makes the method appear somewhat formidable to the nontechnical individual who is accustomed to the simplicity of the water-column test. Furthermore, it is desirable to test with water alone and dispense with solutions as they involve possible extraneous influences of dissolved substances. The investigation was, therefore, continued in an effort to devise some sensitive means of detecting transuded moisture. A satisfactory method resulted from the use of a ground-glass surface in contact with the paper. Application of this method to general testing purposes has been described in previous publications by the originator, F. T. Carson.[3]

The ground-glass method depends upon the principle of capillary adsorption. In small capillaries the vapor pressure of water vapor is less than it would be in the open. Such capillaries, therefore, have the ability to condense water from water vapor under suitable conditions. The myriad small fissures and irregularities of a ground-glass surface, coupled with the change in the apparent index of refraction due to these same fissures and irregularities, are ideally suited to the detection of moisture passing through paper. If one side of a specimen of paper is placed in contact with a ground-glass surface and the other is subjected to a small head of water, the moisture penetrates through the paper and is rendered visible by

[2] Wochenbl. f. Papierfabr., p. 39; 1920.

[3] "Testing waterproofed paper," Paper Trade Jour., **79**, No. 10; Sept. 4, 1924. "Testing paper for permeability to liquids," Paper Trade Jour., **80**, No. 10; Mar. 5. 1925.

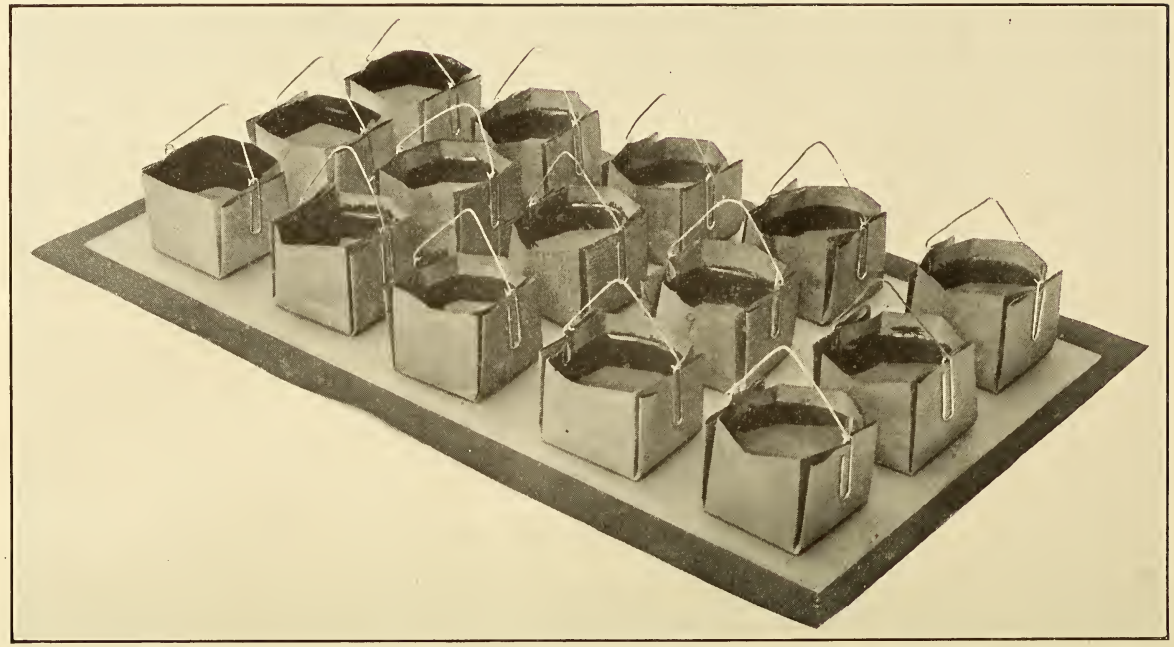

Fig. 1.—*Photograph illustrating the ground glass method for testing water resistance of paper*

wetting or condensing on the ground surface. A dark background for the ground glass facilitates detection of the moisture film. The method is illustrated in Figure 1. The precise method of procedure is described in the specifications at the end of this publication. Table 1 gives comparative results by this method, the modified Stöckigt test, and the customary water-column test and shows well the inadequacy of the water-column test.

TABLE 1.—*Results of different methods of testing water resistance of papers*

Sample number	Description	Weight, 25 by 40, 500 sheets	Method used		
			3-inch water column	Modified Stöckigt	Ground glass
		Pounds		*Minutes*	*Minutes*
1	White writing	78	Moist overnight	1.5	2
2	White ledger	109	do	3	3
3	do	165	do	6	5
4	Kraft wrapping	68	Uncertain	2	4
5	Rope manila	93	Moist overnight	2	4
6	Cement bag	190	Indefinite period	20	15
7	Cloth-back asphalt	66	Two weeks	15	15
8	do	125	Indefinite period	30	120
9	do	169	do	75	195
10	Duplex asphalt, crêped	145	do	60	330
				Hours	*Hours*
11	Duplex asphalt	112	do	12	22
12	do	108	do	10	34
13	do	186	do	6	36
14	do	262	do	19	72
15	do	118	do	67	72

NOTE.—Samples 7 to 15 are waterproofed wrappings used for case-lining and similar purposes.

The chief disadvantage of the ground-glass method is the necessity of lifting the specimen in order to observe the moisture film beneath it. But this occasions no difficulty in the case of a specified minimum time period during which no transudation shall occur, since it is only necessary to lift the specimen at the end of this period of time. Objection has also been made because of the possibility that water vapor may give a test by this method without the actual transudation of water in the liquid phase. But this possibility is a point in favor of the method for the reason that the purpose of the case-lining paper is to exclude moisture in any form from commodities in transit or storage. The same amounts of moisture, either liquid or vapor, gaining access to the contents of a package will prove equally detrimental for the reason that hygroscopic substances and surfaces, in general, have characteristic moisture equilibria in relation to the relative humidity of the air in contact with them. A small amount of moisture in either form entering a wrapped package first increases the relative humidity of the inclosed air, and then a part of it is deposited as the result of the establishment of a new moisture-content equilibrium. Paraffined paper is a good example of a wrapping paper which is water repellent but is not very resistant to water vapor unless a

continuous film of paraffin exists. Although heavy paper paraffined so as to have a continuous film on the surface is highly impervious to moisture as long as the film is not broken by creasing or other injury, the usual lightweight paraffined paper is not very resistant to moisture. Its behavior is not unlike that of a fine metal sieve. Experiments with the lighter paraffined papers have shown that such papers do not readily permit water to pass through them until the atmosphere in contact with the dry side is confined. As soon as this occurs, as would be the case in a wrapped package, the water vapor which passes through increases the relative humidity in the confined space until sufficient moisture is adsorbed in the pores of the paper to allow water to wet through. When once started the water fairly streams through.

Although temperature is a factor in any test of the permeability of liquids, it does not seem practicable to specify it closely in this case. Temperature affects both the viscosity of water and the facility with which the ground glass detects moisture; but the two effects are opposite in sense and tend to compensate each other. A lower temperature decreases the rate of penetration of the water, but increases the sensitivity of the ground-glass surface to the detection of small amounts of moisture, since adsorption is favored by decrease of temperature. Therefore, in view of the difficulty of maintaining a constant temperature over a 24-hour period, it was deemed sufficient to specify that the water be at room temperature; that is, between about 65 and 90° F.

IV. STRENGTH

1. METHOD OF TEST

It is believed that the bursting test is satisfactory for measuring the strength of the paper. Considering the manner of using the paper, a folding endurance test would possibly give additional valuable information, but such a test requires carefully controlled atmospheric conditions, and it is thought that the creasing of the paper in the water-resistance test gives adequate indication of too great brittleness.

2. INFLUENCE OF ASPHALTUM ON STRENGTH

Tests of a number of samples of duplex asphalted papers showed that the bursting strength was generally much greater than the estimated combined strength of the two sheets of the basic kraft paper used in their manufacture. It seemed evident, therefore, that the layer of asphaltum was lending an appreciable degree of strength to these papers. To find more definitely if the strength of this type of paper is due partly to the asphaltum, additional samples

of case lining were tested for bursting strength, the asphaltum extracted, and the bursting strength of the remaining basic paper determined. The following results obtained with samples from four different manufacturers, indicate that the asphaltum does lend considerable strength to the paper:

TABLE 2.—*Strength of waterproofed case-lining paper compared with its strength after extraction of the asphaltum*

Sample number	Bursting strength of case-lining paper	Combined bursting strength of the two kraft sheets after extracting
	Points	*Points*
1	88.5	69.9
2	86.9	70.0
3	77.9	71.0
4	84.6	69.1

It was found that extracting ordinary kraft wrapping paper has some influence upon the strength of the paper though this was not of the magnitude found in the case-lining papers. To obtain more definite information, however, additional samples of case-lining paper, together with the basic kraft paper used in its manufacture, were obtained and bursting tests of both were made. The samples represented the products of eight manufacturers. The results are given in Table 3.

To obtain figures that would be comparable with those obtained for the finished paper, the two basic sheets were tested after placing them together.

TABLE 3.—*Strength of waterproofed case-lining papers compared with the strength of the basic kraft papers*

Sample number	Basic kraft paper, two sheets [1]		Case-lining paper	
	Weight, 25 by 40, 500 sheets	Bursting strength	Weight, 25 by 40, 500 sheets	Bursting strength
	Pounds	*Points*	*Pounds*	*Points*
1	151.2	121.0	191.4	122.1
2	80.1	64.8	115.9	83.8
3	72.0	70.6	107.2	75.9
4	74.3	70.0	128.2	82.6
5	157.4	91.1	220.7	100.1
6	211.1	115.6	264.0	83.5
7	74.8	71.6	117.9	84.7
8	74.1	68.4	119.1	81.1
9	77.3	73.6	106.3	78.8
10	69.7	63.4	114.1	75.6

[1] Two sheets tested together.

The results show in all except two cases an appreciable increase in strength of the case-lining paper over that of the two sheets of kraft paper used in its manufacture. In these two cases the bursting strength values of the basic kraft papers indicate that they were deficient in strength in proportion to their weight. These results confirm those obtained by extracting the asphaltum, giving additional evidence that the asphaltum does increase the strength of the paper, but, whatever the reason for the difference in strength may be, the fact is shown definitely that when the best quality of kraft is used as the base the strength of the case-lining paper is appreciably greater than that of the kraft base alone, and, therefore, in order to assure the use of the best quality of kraft in making the paper it is necessary to provide for this additional strength in specifying the strength of case-lining paper.

V. SPECIFICATIONS

With an adequate water resistance test method available, it is believed that, in addition to water resistance, the only properties requiring detailed specification for waterproof case-lining paper of satisfactory quality are weight and bursting strength.

Additional details suggested for inclusion in specifications by manufacturers and others cooperating were loss in bursting strength after wetting a given length of time, weight of sheets of basic paper and asphaltum, and melting point of asphaltum. It is believed that specifications should be made as simple as possible, avoiding all unnecessary requirements, the object to be striven for being to define, as far as possible, the required performance of a material and allow the manufacturer as much latitude as possible in meeting the requirements. Experiments have shown that with an adequate water-resistance test available the wet bursting-strength test is superfluous. The paper loses strength in proportion to the degree it becomes wetted and, therefore, this test is simply an unnecessary water-resistance test. Specification of the weight of the basic kraft paper and of the asphaltum are not considered necessary. To determine these weights, extraction of the asphaltum is required and this is a tedious and troublesome test and of doubtful value. Determination of the melting point of the asphaltum has the same objection and is considered unnecessary as too high melting asphaltum, which might cause brittleness, is guarded against by the creasing of the paper in the water-resistance test.

It is believed that the following specifications are entirely adequate for paper of satisfactory quality. These were formulated after securing test data of 13 different samples of duplex asphaltum waterproofed case-lining papers, representing the products of nearly all

domestic manufacturers. The results of the tests are given in Table 4. In addition to the data required for formulation of the specifications, thickness, tensile strength, and tearing resistance tests were made as a matter of additional information and the results of these are included. Besides the standard basic weight of 25 by 40 inches, 500 sheets, which has been generally adopted by the paper industry, weight is also expressed on the wrapping paper trade custom basis of 24 by 36 inches, 480 sheets, as a matter of information. Both the actual bursting strength and the bursting strength calculated to a common weight of paper (109 pounds, 25 by 40 inches, 500 sheets) for comparison, are included.

TABLE 4.—*Tests of waterproofed case-lining papers*

Sample number	Weight, 25 by 40, 500 sheets	Weight, 24 by 36, 480 sheets	Bursting strength	Bursting strength on 109-pound paper	Thickness	Tensile breaking strength, per inch width		Tearing resistance		Water resistance [1]
						Machine	Cross	Machine	Cross	
	Pounds	*Pounds*	*Points*	*Points*	*Inch*	*Pounds*	*Pounds*	*Grams*	*Grams*	*Hours*
1	186 4	154. 6	118. 0	69. 0	0. 0154	68. 3	45. 0	----------	----------	36
2	117. 6	97. 5	86. 3	80. 0	. 0060	62. 6	27. 9	198. 4	155. 2	72
3	262. 2	217. 5	123. 9	51. 5	. 0174	76. 3	45. 0	432. 0	398. 4	72
4	135. 4	112. 3	81. 4	65. 5	. 0070	61. 0	30. 1	191. 2	179. 2	72
5	121. 1	100. 4	85. 5	77. 0	. 0069	64. 3	23. 9	226. 4	182. 4	72
6	110. 1	91. 3	86. 8	85. 9	. 0064	59. 9	25. 1	208. 0	141. 6	72
7	114. 3	94. 8	81. 7	77. 9	. 0066	65. 1	24. 0	223. 2	162. 4	72
8	121. 8	101. 1	75. 6	67. 7	. 0068	64. 9	26. 6	207. 2	148. 0	72
9	102. 9	85. 3	85. 7	90. 8	. 0059	64. 7	27. 3	176. 8	135. 2	72
10	146. 8	121. 8	134. 0	99. 5	. 0081	91. 2	46. 2	307. 2	225. 6	72
11	208. 0	172. 5	151. 2	79. 2	. 0121	125. 0	52. 7	590. 4	369. 6	72
12	101. 4	84. 1	84. 6	90. 9	. 0057	62. 2	30. 0	196. 0	143 2	72
13	106. 8	88. 6	83. 5	85. 2	. 0065	59. 8	26. 8	180. 8	167. 2	72

[1] Ground-glass method.

The specifications recommended as a result of the test data shown and considerations mentioned above are as follows:

SPECIFICATIONS FOR WATERPROOFED CASE-LINING PAPER

I. REQUIREMENTS

1. COMPOSITION.—Waterproofed case-lining paper shall consist of two sheets of 100 per cent sulphate fiber kraft paper cemented together with a layer of asphaltum.

2. WEIGHT.—The weight shall be 109 pounds per 500 sheets, 25 by 40 inches in size. A tolerance of ±10 pounds is permissible.

NOTE.—The weight given is equivalent to 90 pounds for the trade custom basis ream of 480 sheets, 24 by 36 inches in size.

3. BURSTING STRENGTH.—The bursting strength shall be not less than 70 points.

4. WATER RESISTANCE.—When tested by the ground-glass method there shall be no transudation of moisture through the paper within 24 hours.

II. METHOD OF INSPECTION AND TEST

1. Sampling.—The test samples shall consist of at least 20 sheets, 11 by 11 inches in size, so selected as to be representative of the entire lot of paper.

2. Strength Test.—The bursting strength shall be determined with a machine by which the paper is firmly clamped against a rubber diaphragm through which pressure is applied to a free circular area of the paper measuring approximately 1 square inch. The readings on the pressure gauge on such instrument shall be recorded as "points."[4] Ten tests shall be made, and the average of the results compared with the requirement in Section I, 3.

3. Water-Resistance Test.—Five specimens, 6 by 6 inches in size, shall be folded through the center, making two creases at right angles to each other, then folded to form boxes 2 inches square and 2 inches high, open at the top, the tabs formed by folding being held by convenient fasteners, such as paper clips. The paper boxes shall be placed on the ground surface of a piece of ground glass resting on black paper or other suitable dark surface. The boxes shall be filled to within one-half inch of the top with water at 65 to 90° F temperature. They shall be lifted at the end of 24 hours and the ground glass under them observed for transuded moisture, this being visible as a dark film on the surface of the glass.

Note.—When transudation of moisture occurs, if the dark film takes the form of the creases in the bottom of the box, this indicates that the lack of water resistance is due to brittleness of the asphaltum.

Washington, December 17, 1925.

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[4] Approximately pounds per square inch.