THE EFFECTIVENESS AND PERMANENCE OF CERTAIN MOISTURE REPELLENT AND STAIN RESISTANT FABRIC FINISHES

by

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TABLE OF CONTENTS

INTRODUCTION

Proper clothing plays an important role in the maintenance of a constant temperature of the body. Clothing should insulate the body and prevent it from losing too much heat and at the same time permit the escape of excess heat and water vapor (19). Therefore, it is important that materials used for clothing possess the qualities that will provide for this.

Until recent years water repellent finishes for fabrics were applied as a coating to the surface in the form of waxes, oils, asphalt, paints, varnish, rubber and metalic soap. These formed a continuous film which closed the interstices of the fabric, and thus rendered them undesirable for clothing that comes in direct contact with the body (11).

Today fabrics are available in which a moisture repellent treatment has been applied to the fibers instead of the fabric (13). Thus a material is produced which is as permeable to air as the untreated fabric of the same construction, yet these finishes are said to repel water and stains and to be permanent to laundering and dry cleaning (15).

"Zelan", first introduced to the American markets in 1939, is a widely known repellent fabric finish. In England this finish is known as "Velan" (12). "Zelan" is a long chain quarternary ammonium compound (18) entirely different from the older type of repellents. It contains no rubber, wax or insoluble soap. "Zelan" is said by the producers to unite chemically with the fabric to which it is applied (22). The concentration suggested is six percent "Zelan" based on the dry weight of the sample.

Aridex another special finish on the market is also recommended to impart a high degree of repellency and is praised for its ease of application (1). Aridex is a wax emulsion and is classified (along with other wax, inert fats, aluminum soap and acetates or formates) as an old type finish (18). Aridex finish can be applied to garments during the laundry process. The concentration recommended is two to six ounces per gallon of water or precooked starch and a temperature of 100 to 120° F. These finishes add to the fabric a softness of handle and make no visual change in the appearance of the fabric (10) (Plate I).

These finishes may be applied to fabrics suitable for use in the manufacture of all wearing apparel (1). Therefore, it is important to know the durability of these finishes as well as their water repellent and stain resistant qualities (4).

The purpose of this study was to ascertain the effects of certain finishes on the moisture repellent qualities and stain resistance of selected fabrics; and to determine the extent to which these finishes are permanent to laundering and dry cleaning.

EXPLANATION OF PLATE I

Control fabrics treated and untreated used in this study.

A	Organdy	"Zelan"	treated
B	Broadcloth	"	"
C	Poplin I	"	"
D	Poplin II	Aridex	"
E	Organdy	untreated	
F	Broadcloth	"	
G	Poplin I	"	
H	Poplin II	"	

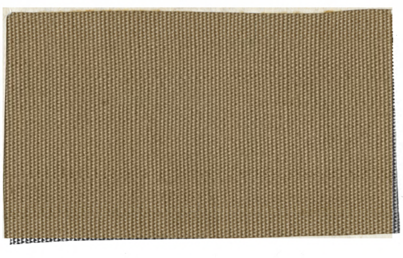
PLATE I

A

B

C

D



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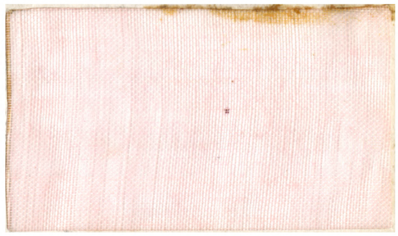

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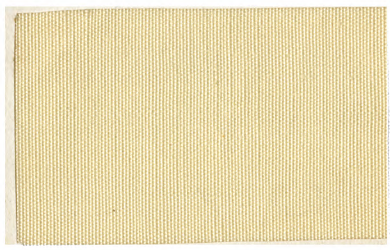

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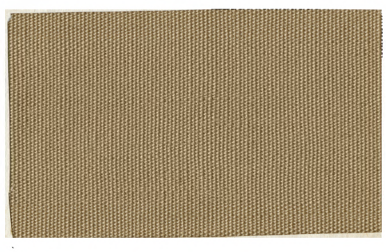


REVIEW OF LITERATURE

Many tests have been conducted which measured the absorption of moisture by fabrics and methods have been recommended for these tests, however, few studies were found which determined the permanency of moisture repellent and stain resistant finishes to cleaning.

Cook and Zaparanic (2) developed a test for moisture absorption when water is sprayed on the fabric. A weighed sample was sprayed under controlled conditions and then reweighed to determine the amount of water absorbed. They stated that this method was useful in comparing two or more products for water repellency. They concluded that it is capable of semi-quantitative results and no expensive apparatus is required.

Stiegler and Hood (20) discussed the spray method developed by Cook and Zaparanic. They concluded that with certain modifications the spray test provided an accurate quantitative and reproducible method of evaluation and that all tests should be carried out with accurate control of water temperature.

Koons (8) by means of the spot test studied the effect of water proof and water repellent finishes consisting of metallic soap, zinc aluminum, and copper combined with organic protective colloids such as waxes, gums and glues. He reported that these finishes made silk hose snag resistant as well as water repellent.

Stenzinger (21) stated that the first methods for testing the water proofness or water repellency of fabrics were developed at the same time as the development of moisture repellent finishing processes. He reviewed methods for impregnating fabrics with a combination of aluminium salts and soap. These processes have continued with various changes. At this time the three following methods for testing fabrics were developed: (a) immersion of the dry sample of known weight in water for 24 hours; (b) subjection of the dry weighed sample to the impact of rain for one hour; and (c) keeping the dry sample of known weight in a moist atmosphere over night. In each case the increased weight was determined. He also designed the trough test. In this the fabric was folded in the form of a trough capable of holding a definite amount of water. The penetration by the water through or into the cloth was observed over various periods of time. This test was used for many years in preference to all others, although it was not entirely satisfactory for fabrics suitable for clothing. In this study Stenzinger described many other tests and grouped them under five main headings, namely, pressure from above, pressure from below, pressure from all sides, dropping or sprays, and water absorption.

Furry and Weidenhammer (5) tested the absorptive qualities of water repellent finishes of cotton hose. In this study both the spot and emersion methods were used to test the absorptive properties of a number of differently treated cotton hose.

The results reported were that a significant difference existed in the percentage of water absorbed by the treated and untreated hose. They concluded that the effect of a finish can be very great, but only a few of the finishes studied imparted a high degree of water repellency to the hose. For the most part the results obtained with both the immersion test and the spot test gave the same results.

They also reported that the spotting test, especially suitable for testing water repellency of hosiery, is essentially a method for measuring resistance to absorption. The section to be tested was fastened taut, but not stretched, over the top of a beaker. From a small pipette 0.1 ml of water was placed on the hose and the absorption timed with a stop watch. Absorption was considered complete when the little water films visible in the meshes of the hose broke and disappeared. If absorption was complete within five minutes, the time in seconds was recorded. If the drop was not appreciably absorbed within five minutes a time of 300+ seconds was reported. The unabsorbed drops were shaken off and the condition of the surface noted.

Six designations were set up as a rating scheme for the condition of the surface; (a) surface slightly wet, (b) wet, (c) very slightly absorbed, (d) slightly absorbed, (e) partly absorbed, and (f) greatly absorbed. Time went as high as five minutes.

Slowinsky (17) stated that the problem of measuring and evaluating water resistant finishes could be simplified if the fabrics in question fit certain definitions. He suggested a set of definitions advanced by Pearson in 1924. "Water proof means; Impervious to water and air resistant." Water resistant means; "Resistant to water and porous to air." Based upon these definitions Slowinsky in connection with the A. T. C. C. made an extensive survey of standards for water resistent fabrics and the testing methods to be used. He discussed an immersion test to measure the resistance of a fabric to the absorption and retention of water. A weighed sample of fabric was immersed for 20 minutes in water at 80±2° F. removed and placed between two sheets of blotting paper. It was then squeezed through a wringer to remove excess water and reweighed. The increase in weight was calculated as the percentage absorption based on the original air dry weight of the sample.

Slowinsky stated that the acceptance of Pearson's definitions as stated above would make possible the acceptance of the procedure recommended by Scott.

Scott (16) gave the following requirements on which modern textile resistance to the wetting action of water depended: strong resistance to water under some pressure, moderate resistance to penetration by fall-water such as rain and resistance to actual wetting by water.

He outlined the various procedures used in the trade to measure the three properties of water resisting finishes as follows:
(a) tests which measure the hydrostatic pressure required to cause "break down" of a fabric, and tests which measure leakage through a fabric under a fixed hydrostatic pressure such as bag tests, box tests and funnel tests; (b) surface repellency tests which measure surface wetting and penetration under the influence of falling water, such as spray tests, dropping tests and faucet tests; and

(c) absorption tests which measure the absorption of water by a fabric when immersed or manipulated under water.

Larose (9) in a study for measuring the water absorption by towels discussed three test methods (a) the cylindrical portion of an aluminum thimble was covered with a thin leather strip and the portion not covered was made impervious to water by means of wax. The thimble was connected to a water reservoir by means of a tube passing through the cork that closed the thimble. The water pressure could be adjusted by varying the height of water in the reservoir. This pressure was so adjusted that water seeped through the leather and coated it with a thin film. This was not satisfactory due to the difficulty found in maintaining a constant film on the surface. (b) The top of a shallow receptacle was closed with a porous plate, sealing it with wax and connecting this apparatus to the reservoir. The plate was not porous enough to make the test satisfactory. (c) He considered the method as used by Hess and Reidheimer (6) as the most efficient.

According to Furry (5) Brendlesman in a series of published photographs showed clearly the marked water repellency of a treated fabric in contrast to the untreated. These pictures illustrated in great detail the actual processes occurring when falling drops strike the surface of fabrics. He concluded that the processes occurring are not always the same but are greatly influenced by the character of the surface of the material.

PROCEDURE

Eight fabrics were used for this study. The same fabrics with and without repellent finishes were obtained from the manufactures. These consisted of cotton poplins finished with "Zelan" and Aridex, and the same fabrics without repellent finishes; and cotton broadcloth with and without "Zelan" finish. Organdy with "Zelan" finish and organdy without water repellent finish were purchased on the retail market.

Five yards of each fabric were purchased and these were divided into three parts, one of which was held as control, one laundered 10 times, and the other dry cleaned five times. A portion of all fabrics before and after dry cleaning and laundering was used for tests of water repellence and stain resistance.

Analysis of Fabrics

The fabrics were analyzed for the following: width, thread count, yarn counts, percentage crimp, weight per square yard, breaking strength and stretch, effect of abrasion, percentage of sizing and amount of finish (Tables 1, 2 and 3).

An abrasion machine designed at the Massachusetts Institute of Technology was used to determine resistance to abrasion, and the percentage of crimp was measured by the Schwarz method using a camera lucida. For the abrasion two 6 x 24 inch strips (one warp and one filling) were taken from each control fabric. The

Table 1. Physical characteristics.

Fabrics treated	Width in.	Thread count warp	Thread count filling	Yarn counts in Typp system warp	Yarn counts in Typp system filling	Percent crimp warp	Percent crimp filling	Wt. per sq. yd. in oz.
Organdy "Zelan" treated	40	80	70	58.5^{s}	74.0^{s}	1.5	5.4	1.4
Broadcloth "Zelan" treated	36	142	58	37.1^{s}	21.0^{s}	8.1	12.6	4.1
Poplin I "Zelan" treated	36	105	52	19.5^{s}	13.9^{s}	14.9	3.8	6.2
Poplin II Aridex treated	37	116	48	17.3^{s}	14.3^{s}	8.1	9.4	6.8

Table 2. Weight in grams of 20 square inches of the treated and untreated fabrics and the difference in weight of the treated and untreated.

Fabrics	Control	% Dif.	Laundered	% Dif.	Dry cleaned	% Dif.
Organdy, untreated	.5596		.6210		.6174	
" "Zelan"treated	.6057	0.5	.6388	2.9	.6487	5.1
Broadcloth,untreated	1.8015		2.0349		1.9341	
" "Zelan"treated	1.7971	-.2	2.0568	1.1	2.0342	5.1
Poplin I, untreated	2.6767		2.9381		2.8693	
" I,"Zelan"treated	2.6907	0.5	2.9098	-1.0	2.8065	-2.2
Poplin II,untreated	2.7627		3.0059		2.8519	
" II,Aridex treated	2.7717	0.3	2.9327	-2.4	2.9003	1.7

Table 3. Breaking strength in pounds and stretch in inches of the control and abraded fabrics.

Fabrics	Controls				Abraded			
	Breaking strength		Stretch		Breaking strength		Stretch	
	warp	filling	warp	filling	warp	filling	warp	filling
Organdy untreated	24.8±0.3	13.3±0.4	.11±.02	.15±.00	24.4±0.4	13.0±1.0	.15±.01	.16±.01
Organdy "Zelan"treated	16.0±0.5	7.5±0.2	.15±.01	.18±.01	14.2±0.3	4.7±0.2	.15±.00	.14±.01
Broadcloth untreated	60.3±0.7	45.0±1.2	.28±.01	.26±.01	50.9±1.6	42.4±1.0	.29±.00	.22±.00
Broadcloth "Zelan"treated	48.0±0.7	38.5±0.4	.28±.00	.21±.00	26.3±1.4	33.0±0.4	.18±.00	.17±.01
Poplin I untreated	122.6±1.9	92.7±1.3	.50±.00	.32±.01	83.8±4.4	82.0±1.5	.45±.01	.27±.01
Poplin I "Zelan"treated	107.5±1.5	72.4±0.0	.38±.01	.27±.01	87.6±1.7	66.9±0.1	.35±.01	.27±.00
Poplin II untreated	117.9±4.0	91.5±1.1	.49±.00	.30±.00	99.3±2.7	81.4±1.7	.47±.01	.27±.00
Poplin II Aridex treated	125.6±3.4	68.1±1.0	.50±.00	.25±.00	111.8±1.8	63.6±1.1	.45±.01	.26±.00

poplins were given 1000 strokes, the broadcloth 500 and the organdy 200.

All other physical tests were made according to standards set up by Committee D-13 (3). Breaking strength and stretch tests were made on the controls and also on the laundered and dry cleaned portions of all fabrics (Table 3).

A specimen of one fabric finished with "Zelan" and one finished with Aridex were tested for percentage sizing. The carbon tetrachloride and enzyme method as set up by Committee D-13 (3) and the nitric acid test as prescribed by Howlet and Urquhart (7) were used. Two five gram samples of the fabric after drying were boiled in 400 ml of 0.1 N solution of nitric acid for exactly 10 minutes, rinsed in distilled water until neutral and the amount of finish calculated.

Attempts were made to measure the absorption of the fabrics by means of Haven's strip method as modified and reported by Hess and Reidheimer (6). Water would not pass along the fabrics so this method could not be used.

Because there seemed to be no agreement among investigators as to a satisfactory means of removing the surface moisture from the test specimens, and because repellent finished fabrics were usually worn as outer clothing it was decided to measure the amount of moisture that passed through the fabric rather than the amount absorbed by it.

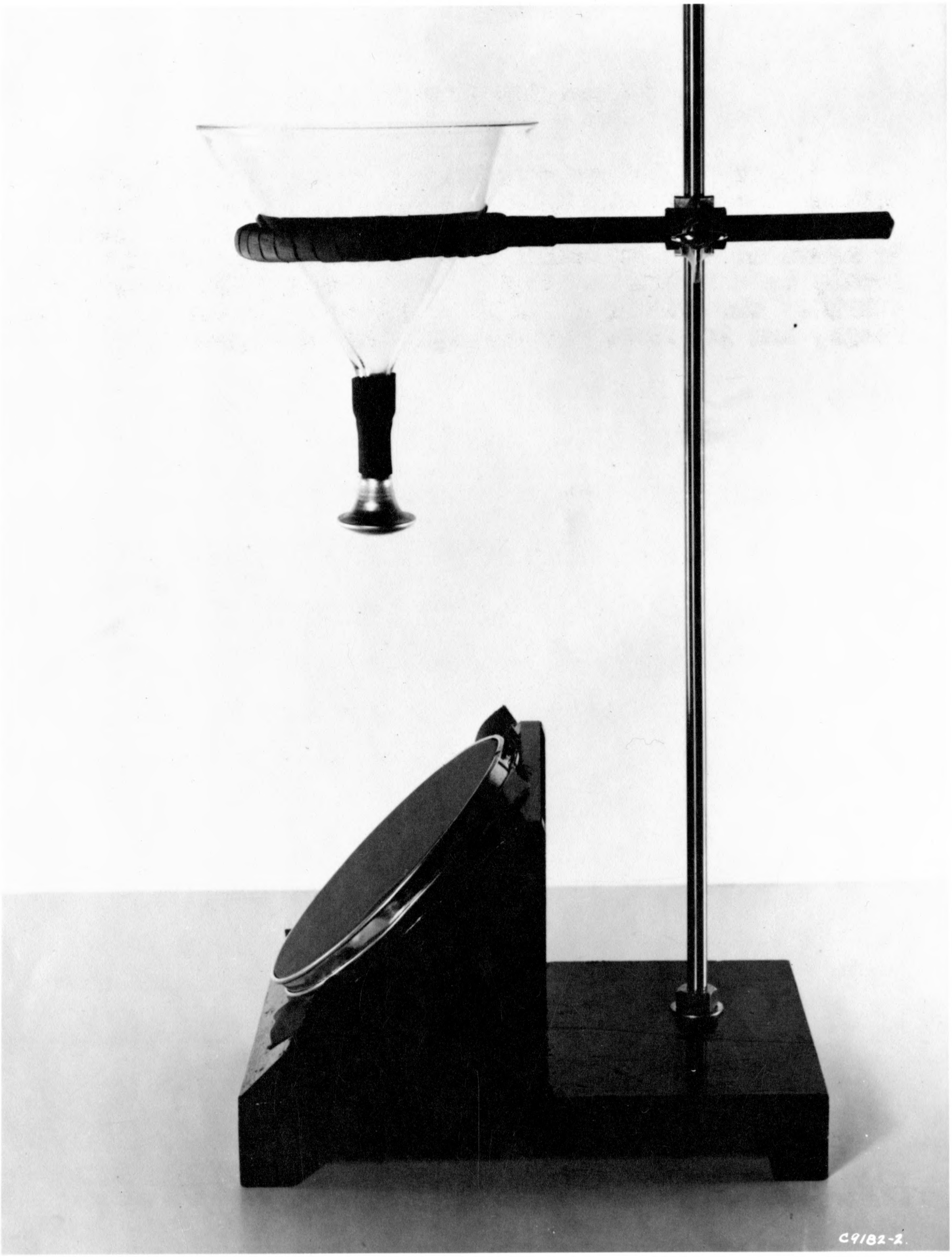
The modified wet disk method of water absorption as reported by Hess and Reidheimer was used for this purpose. This method consisted of placing the test specimens on a moist disk which was kept at a constant water level in a shallow pan of distilled water (6). The amount of moisture that passed through the fabric in a definite length of time under a known pressure was obtained by placing the sample on the disk with a three and three-fourths inch square of standard blotting paper between the sample and the weight. A three and three-fourths inch square of glass weighing 20 g was used next to the blotting paper and the additional pressure obtained by adding 10, 20, or 30 g weights. The squares of blotting paper were weighed before testing. When removed from the disk they were placed in a tarred weighing bottle to prevent evaporation during re-weighing. The fabric and blotter remained on the disk one-half, one, one and one-half, two, three, four, and five minutes. There were three tests made for each interval of time. The pressure ranged from 20 to 50 g by 10 g increases. Eighty-four four by four inch squares from each portion of the fabrics were tested. A fabric was considered to be repellent or non-repellent according to the amount of moisture that passed through the fabric and was absorbed by the square of blotting paper. All work was done in a laboratory maintained at 66±2 percent relative humidity at a temperature 80±2° F.

Moisture penetration and stain resistance of the fabrics were measured by means of an apparatus furnished by the Du Pont Company. This is shown in Plate II. This spray device consisted of a small nozzle attached to a six inch glass laboratory funnel by means of a two inch piece of rubber tubing. The distance from the neck of

EXPLANATION OF PLATE II

The spray device consists of a small spray nozzle attached to a six inch glass laboratory funnel by means of a two inch piece of rubber tubing. The funnel is supported by means of an iron ring so that the bottom of the spray nozzle is a definite height above the fabric center or the fabric. The fabric is held in place by means of two metal rings, and is placed at an angle of 45 degrees.

PLATE II



the funnel to the bottom of the nozzel was three inches. The funnel was supported by means of an iron ring so that the bottom of the spray nozzle was a definite vertical distance or height above the center of the fabric when it was placed in position (18). The fabric was held taut by means of two metal rings, and was placed on the stand at an angle of 45 degrees (Plate II). Three seven inch squares were cut from the control, laundered and dry cleaned portions of all the fabrics. A square was attached to the apparatus and subjected to coffee, grape juice and ink. Into the funnel was poured 250 cc of the liquid within 20 seconds and sprayed on to the fabric. After the dropping ceased the sample was removed immediately from the apparatus and rinsed in cold water. If this did not remove the stain warm water was used. If the stain persisted after the sample was rinsed in cold and warm water it was then washed in warm soap suds. If warm soap suds failed to remove the stains the fabric was sent to a commercial laundry. Only a visual test was used to determine whether or not the stain persisted.

FINDINGS AND DISCUSSION

The fabrics used in this study were types that are suitable for the construction of such wearing apparels as dresses, uniforms, sport suits, and shirts.

The results of fabric analysis: width, thread count, yarn counts, breaking strength, percentage crimp and weight per square yard are shown in Tables 1 and 3. The percentage differences in the weight per square yard of the treated and untreated fabrics are shown in Table 2.

The relative wearing qualities of the fabrics studied were determined by comparing the breaking strength and stretch of the controls with that of the abraded fabrics. There was a greater difference between the breaking strength of a treated and an untreated fabric in both "Zelan" and Aridex finishes in the controls than between these fabrics after abrasion. The breaking strength of the control of the "Zelan" treated fabrics was less than that of the same fabrics without this treatment. But in the case of the Aridex finished fabric the treated fabric was slightly stronger than the untreated. The stretch of the treated fabric was less than that of the untreated of the same material with the exception of the organdy in which the stretch of the treated fabric was slightly more. Abrasion reduced the stretch of all fabrics (Table 3). There was only a slight increase in the weight per square yard of the treated over the untreated fabric except in the organdy. In this the two fabrics had not been purchased from the same source so could not be compared (Table 1).

The "Zelan" treated broadcloth and Aridex treated poplin were tested for sizing by extracting with carbon tetrachloride, a solublizing enzyme, and with 0.1 N solution of nitric acid. The amount of sizing removed by subsequent treatments of the fabric was very small. The carbon-tetrachloride-enzyme treatment removed 1.2 percent from the "Zelan" finished broadcloth and the nitric acid solution 0.6 percent. The percentage sizing removed from the Aridex treated fabric was 2.3 by carbon tetrachloride and enzyme and 2.0 by nitric acid.

At the beginning of the work it was thought wise to use one-half minute intervals but a study of the data revealed that there was not enough difference between the amount of moisture absorbed by the blotter in one-half minute and one minute to justify the tabulation. This was also the case with the difference between the absorption during one and one-half and two minutes. Especially was this true in the penetration through the heavier fabrics. Therefore, readings were taken at the intervals of one minute. In attempting to plot the evident absorption under pressure exerted by 20, 30, and 40 g weights, the rate of absorption was so gradual as to present almost a straight line. For the greater weight a curve appeared when the points were plotted (Figs. 1 and 2).

The repellency of the "Zelan" treated organdy both before and after laundering was much greater than the untreated fabrics whether laundered or dry cleaned. But dry cleaning reduced the repellent qualities of the "Zelan" treated organdy to less than the untreated fabric whether control, laundered, or dry cleaned. Table 1 shows that the repellency of the untreated organdy was slightly increased by laundering. No noticeable increase in amount of moisture passed through the treated organdy in one, two, and three minutes under the four different pressures. The amount of moisture that penetrated ranged from .01 in one-half minute under 20 g pressure to .04 at the two minute interval under 50 g pressure. The three, four and five minute intervals, however, showed a varied and also an irregular increase in absorption, the greater amount being .15 in four minutes under 40 g pressure. In some

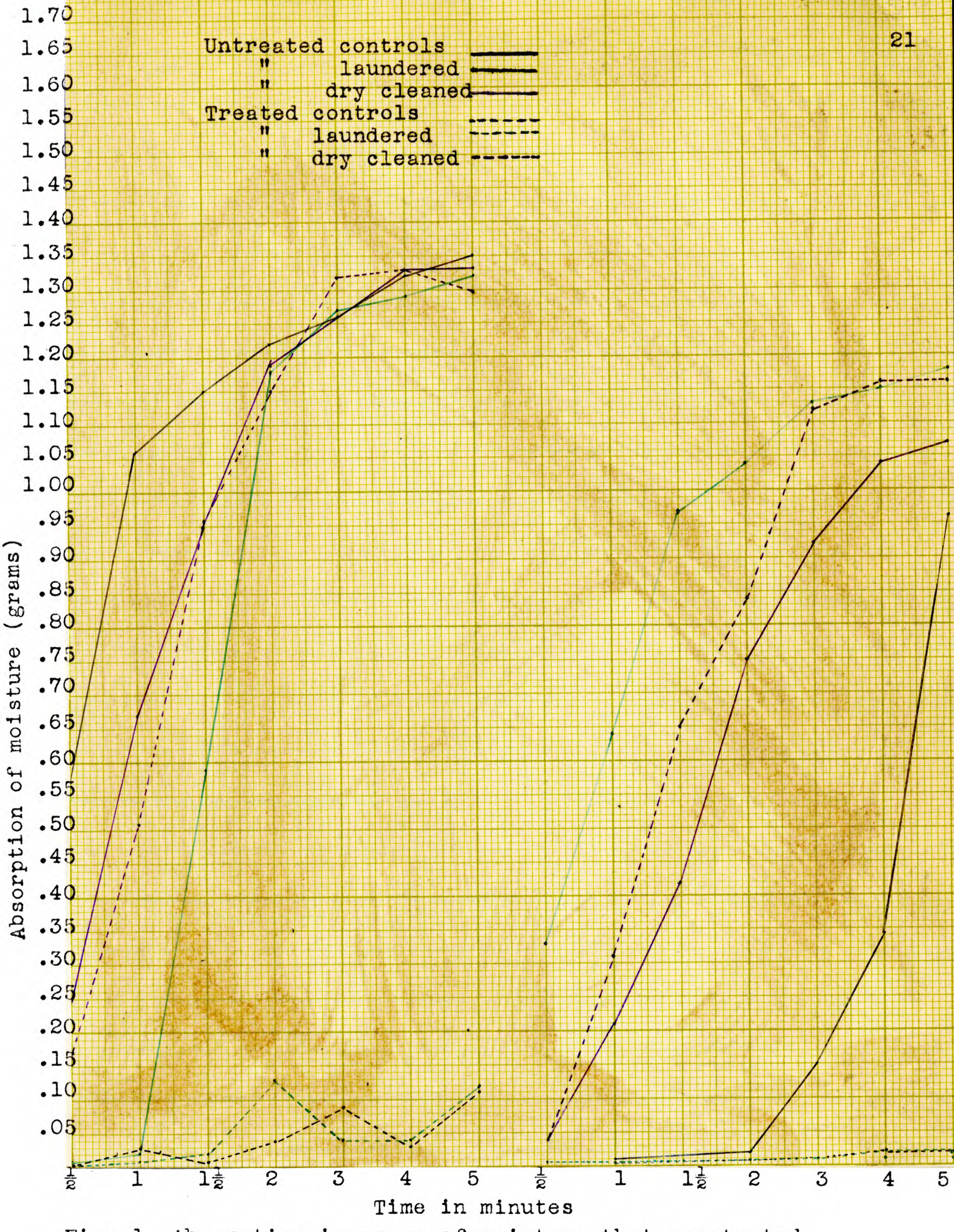


Fig. 1 Absorption in grams of moisture that penetrated "Zelan" treated and untreated organdy and broadcloth before and after laundering and dry cleaning under 50 g pressure.

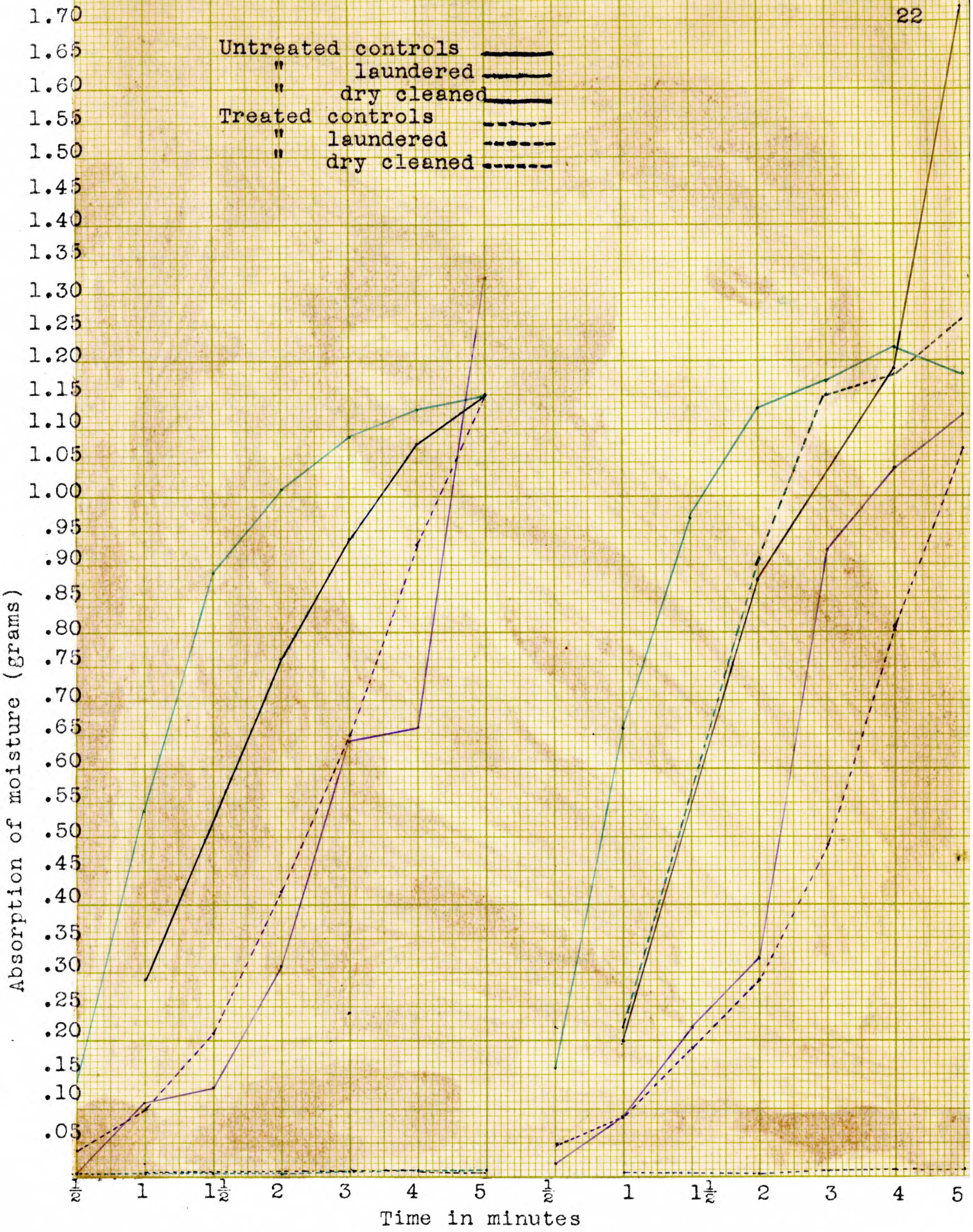


Fig. 2 Absorption in grams of moisture that penetrated "Zelan" treated and untreated poplin; and Aridex treated and untreated poplin, before and after laundering and dry cleaning under 50 g pressure.

instances the squares of blotting paper absorbed more moisture in four minutes than in five. This occurred most frequently under 40 and 50 g pressures and in these cases there was evidence of moisture on the glass. When this occurred the 20 g glass weight was weighed with the blotter. This lowering of the figure under greater pressure and a longer period of time indicated that the blotter became saturated in four minutes and when the five minute stage was reached the moisture had been forced out by the increased pressure (Table 4).

The next heavier fabric, broadcloth, was also "Zelan" treated and showed similar repellent characteristics to that of the "Zelan" treated organdy. Laundering seemed to have no effect on the finish as is shown in Table 5.

The repellency of the fabric was greatly decreased by dry cleaning. This is shown by the fact that the amount of moisture that passed through the fabric after dry cleaning was greater than that of the untreated fabric after the same process (Table 5).

"Zelan" treated poplin showed a marked degree of repellency in the control. There was no noticeable difference in the amount of moisture absorbed by the fabric in the first two minutes, and .02 g was the highest amount absorbed at any time. This was under 40 g pressure during five minutes (Table 6). The untreated fabric showed a moisture passage of .29 in the first minute and 1.15 g in the fifth. Ten launderings did not impair the finish. There was practically no difference in the moisture penetration of the treated fabric before and after laundering. But laundering great-

Table 4. Absorption in grams of moisture through organdy.

Fabric	Pressure in grams	Controls							Laundered							Dry cleaned						
		Time in minutes							Time in minutes							Time in minutes						
		½	1	1½	2	3	4	5	½	1	1½	2	3	4	5	½	1	1½	2	3	4	5
Untreated																						
	20	.21	.47	.92	1.16	1.20	1.24	1.31	.16	.41	.93	1.13	1.30	1.33	1.31	.17	.44	.64	1.03	1.28	1.48	1.32
	30	.22	.82	1.22	1.25	1.30	1.30	1.35	.18	.41	.99	1.11	1.19	1.33	1.37	.14	.52	1.03	1.17	1.29	1.27	1.35
	40	.49	1.03	1.20	1.25	1.28	1.34	1.33	.22	.78	.11	1.20	1.25	1.34	1.39	.38	.63	1.04	1.18	1.31	1.22	1.35
	50	.57	1.06	1.15	1.22	1.26	1.32	1.35	.01	.02	.59	1.18	1.27	1.29	1.32	.25	.67	.95	1.19	1.26	1.33	1.33
Zelan treated																						
	20	.01	.01	.01	.02	.02	.11	.06	.01	.01	.01	.03	.03	.13	.06	.13	.26	.67	.69	1.21	1.37	1.34
	30	.01	.01	.02	.01	.03	.03	.08	.01	.02	.03	.07	.04	.08	.28	.16	.34	.55	1.15	1.28	1.31	1.39
	40	.03	.01	.01	.03	.09	.15	.04	.01	.04	.02	.13	.10	.13	.15	.18	.49	.99	1.15	1.18	1.28	1.36
	50	.01	.03	.01	.04	.09	.03	.11	.01	.01	.02	.13	.04	.04	.12	.17	.51	.96	1.15	1.32	1.33	1.30

Table 5. Absorption in grams of moisture through broadcloth.

Fabric	Pressure in grams	Controls							Laundered							Dry cleaned						
		Time in minutes							Time in minutes							Time in minutes						
		½	1	1½	2	3	4	5	½	1	1½	2	3	4	5	½	1	1½	2	3	4	5
Untreated	20		.00		.01	.01	.09	.06	.08	.27	.63	.85	1.07	1.13	1.15	.02	.03	.06	.16	.44	.55	.91
	30		.00		.01	.03	.46	.69	.23	.60	.92	1.04	1.10	1.12	1.18	.01	.04	.14	.17	.58	.89	1.08
	40		.00		.02	.11	.70	1.08	.28	.60	.87	1.03	1.13	1.13	1.19	.02	.10	.31	.50	.98	1.04	1.10
	50		.01		.02	.15	.34	.96	.33	.64	.97	1.04	1.13	1.15	1.18	.04	.21	.42	.75	.92	1.04	1.07
"Zelan" treated	20		.00		.01	.01	.01	.02	.00	.00	.01	.01	.01	.02	.02	.03	.05	.21	.41	.87	1.02	1.17
	30		.00		.01	.01	.02	.02	.00	.00	.01	.01	.01	.01	.02	.03	.06	.31	.54	.93	1.06	1.20
	40		.00		.01	.01	.02	.02	.00	.00	.01	.01	.01	.01	.02	.05	.15	.53	.80	1.06	1.15	1.19
	50		.00		.01	.01	.02	.02	.00	.00	.01	.01	.01	.02	.03	.04	.31	.65	.84	1.12	1.16	1.16

Table 6. Absorption in grams of moisture through poplin I.

Fabric	Pressure in grams	Controls							Laundered							Dry cleaned						
		Time in minutes							Time in minutes							Time in minutes						
		½	1	1½	2	3	4	5	½	1	1½	2	3	4	5	½	1	1½	2	3	4	5
Untreated																						
	20		.11		.28	.31	.24	.75	.07	.18	.34	.43	.79	1.02	1.14	.00	.01	.01	.01	.02	.05	.10
	30		.10		.40	.63	.81	.96	.09	.25	.33	.61	.95	1.10	1.15	.01	.02	.03	.05	.89	.56	.67
	40		.24		.63	.83	1.09	1.14	.08	.35	.42	.94	1.10	1.13	1.14	.01	.02	.08	.06	.17	.17	.47
	50		.29		.76	.94	1.08	1.15	.14	.54	.89	1.01	1.09	1.13	1.15	.01	.02	.13	.31	.64	.66	1.32
"Zelan" treated																						
	20		.00		.00	.01	.01	.01	.00	.00	.00	.00	.01	.01	.01	.02	.27	.10	.15	.19	.42	.47
	30		.00		.00	.01	.01	.01	.00	.00	.00	.00	.01	.01	.01	.02	.04	.15	.39	.77	1.01	1.14
	40		.00		.00	.01	.01	.02	.00	.00	.00	.01	.01	.01	.02	.06	.10	.28	.38	.64	.74	.79
	50		.00		.00	.01	.01	.01	.00	.00	.00	.01	.01	.01	.02	.04	.10	.21	.42	.65	.93	1.15

ly increased the moisture penetration of the untreated fabric. The treated fabric showed no repellency after five dry cleanings. The resistance of the untreated dry cleaned fabric was greater at some intervals than that of the treated fabric after dry cleaning (Table 6).

The Aridex treated fabric, poplin II, showed marked repellency in the control when compared with the untreated fabric before laundering or dry cleaning. The penetration of the untreated fabric ranged from .20 g in one minute to 1.72 g in five minutes, while in the treated fabric the highest amount absorbed at no interval was higher than .01 (Table 7). There was a noticeable difference in the penetration through the Aridex treated fabric before and after laundering whereas in the case of the "Zelan" treated fabric the difference was only slight. Laundering seemed to have increased the repellency of the untreated fabric. Table 7 shows that at some intervals the penetration of the untreated was less after laundering than before. The repellency of the treated fabric after five dry cleanings had been reduced to practically that of the untreated fabric.

Absorption by Spray Test

According to the E. I. du Pont rating chart all treated fabrics rated 90-100 in both the control and the laundered portions as they were only surface wetted and the liquid could be shaken off. All dry cleaned fabrics rated zero. This rating chart takes into consideration only the wetting of the upper surface (Plate III).

Table 7. Absorption in grams of moisture through poplin II.

Fabric	Pressure in grams	Controls							Laundered							Dry cleaned						
		Time in minutes							Time in minutes							Time in minutes						
		½	1	1½	2	3	4	5	½	1	1½	2	3	4	5	½	1	1½	2	3	4	5
Untreated																						
	20		.07		.17	.38	.68	1.06	.04	.29	.39	.93	.97	1.10	1.12	.01	.04	.12	.20	.40	.66	1.05
	30		.22		.37	.94	.96	1.21	.08	.23	.57	.89	1.13	1.18	1.22	.04	.41	.19	.17	.40	1.08	1.15
	40		.15		.39	1.18	1.10	1.08	.15	.62	.80	1.06	1.38	1.15	1.15	.04	.14	.25	.40	.85	1.10	1.12
	50		.20		.88	1.15	1.19	1.72	.16	.66	.97	1.13	1.17	1.22	1.15	.02	.09	.22	.32	.92	1.04	1.12
Aridex treated																						
	20		.00		.01	.01	.01	.01		.18		.67	.51	1.11	1.03	.00	.02	.06	.15	.25	.27	.35
	30		.00		.01	.01	.01	.01		.35		.57	.91	1.14	1.13	.02	.03	.13	.20	.39	.62	.78
	40		.00		.01	.01	.01	.01		.40		.92	1.07	1.10	1.16	.03	.08	.23	.26	.61	.91	1.07
	50		.00		.01	.01	.01	.01		.22		.90	1.15	1.17	1.26	.05	.09	.19	.29	.49	.81	1.07

EXPLANATION OF PLATE III

100 No sticking, spotting or wetting of upper surface.

90 Slight sticking or spotting of upper surface.

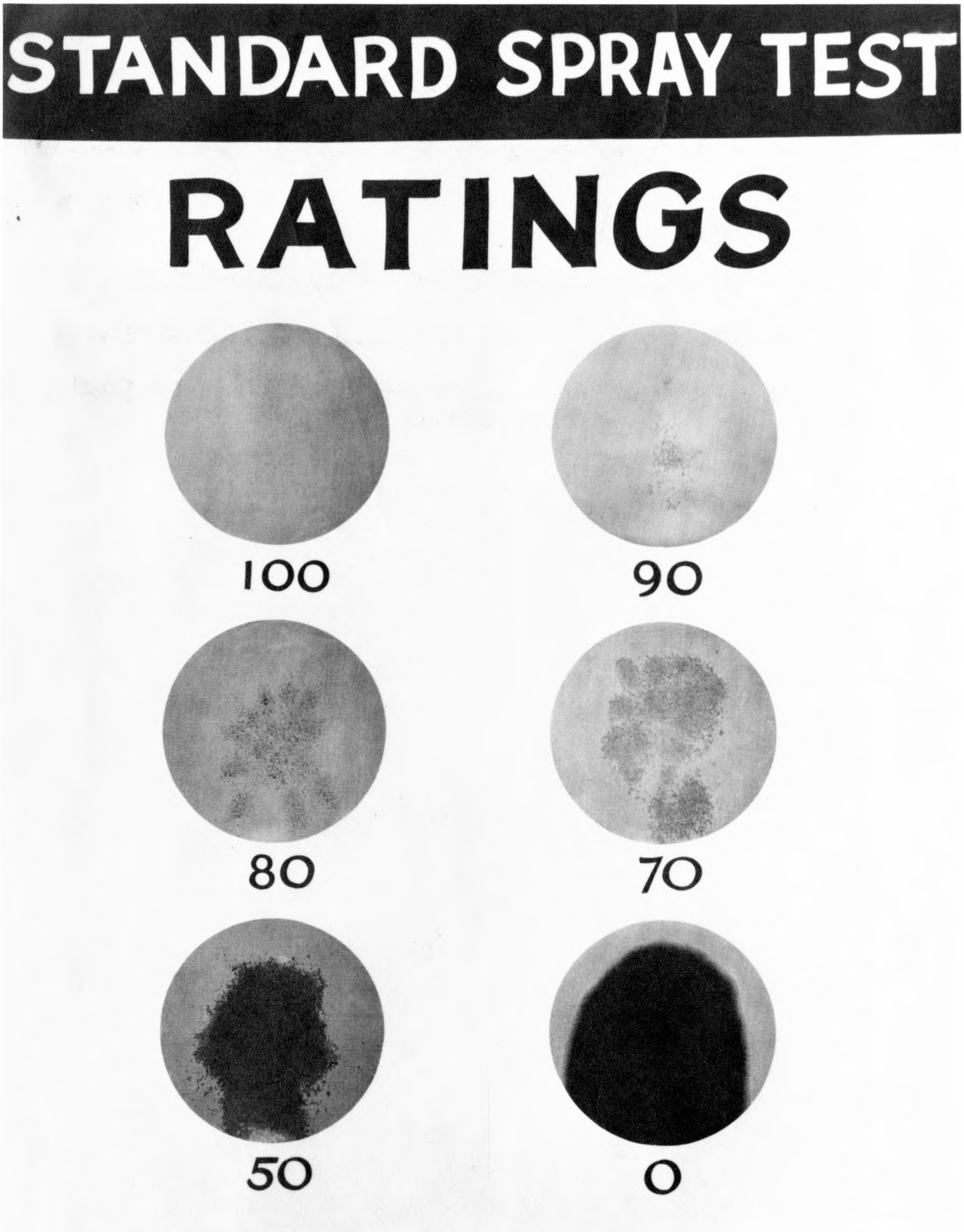
80 Wetting of upper surface at points where water sprays impinged.

70 Partial wetting of whole of upper surface.

50 Complete wetting of whole of upper surface.

0 Complete wetting of upper surface and penetration or wetting through to lower surface.

PLATE III



The under surface of both the laundered portion and the control of the "Zelan" treated organdy was partially wet but appeared to be only surface wet as the water was easily shaken off and when pressed between paper towels with the hand for a few moments the fabric seemed to be thoroughly dry. This was true even after rinsing under running water for stain removals. The dry cleaned organdy was wet through at spray points. The untreated organdy was only partially wet on the under side, a matter which may be due to the ability of the water to pass through the interstices. In the case of the control and laundered specimens in both the "Zelan" and Aridex finished fabrics, the under surfaces showed no signs of moisture evan after rinsing under running water for stain removal. The dry cleaned specimens of both of these fabrics were wet through. The untreated fabric reacted the same as the dry cleaned.

The broadcloth in both the control and the laundered portions showed about the same resistance to water as did the poplins, that is dry under surfaces after rinsing, but the dry cleaned was thoroughly wetted. The untreated fabric was partially dry on the under side, very much the same as the organdy, due probably to its sheerness.

Both the wet disk and the spray tests gave evidence that 10 launderings did very little to remove the moisture repellent qualities of the "Zelan" finish, but that its effectiveness was greatly reduced by five dry cleanings. Laundering, however, changed the appearance of the fabric more than dry cleaning (Plate IV).

EXPLANATION OF PLATE IV

Treated fabrics after 10 launderings and five dry cleanings.

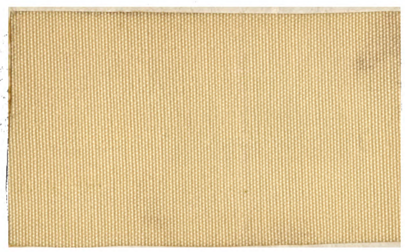
A	"Zelan"	treated	organdy	after	laundering	
B	"	"	broadcloth	"	"	
C	"	"	poplin I	"	"	
D	Aridex	"	poplin II	"	"	
E	"Zelan"	"	organdy	"	dry	cleaning
F	"	"	broadcloth	"	"	"
G	"	"	poplin I	"	"	"
H	Aridex	"	poplin II	"	"	"

PLATE IV

A

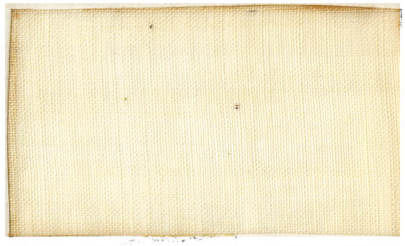
B

C



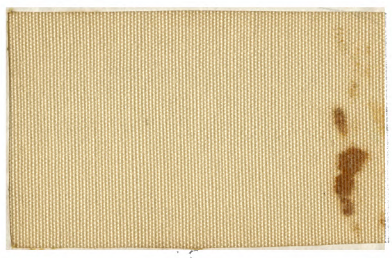
D

E

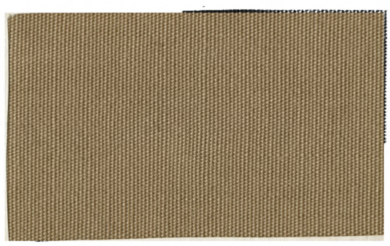


F

G



H



Stains

Coffee stains were removed,by rinsing in hot water, from the untreated organdy and broadcloth that had not been laundered or dry cleaned. But the poplins (I and II) of this group had to be washed in warm soap suds to remove the coffee stains. These stains were removed from the three "Zelan" treated fabrics which had not been laundered or dry cleaned by rinsing in cold water but the Aridex treated fabric had to be washed in warm soap suds. Laundering reduced the stain resistance of most of the untreated fabrics and those treated with "Zelan", but laundering made the stains easier to remove from the Aridex finished fabric. All of the untreated fabrics that had been laundered had to be rinsed in hot water to remove coffee stains. But these stains were removed from the laundered treated organdy and broadcloth by rinsing in cold water. The laundered "Zelan" treated poplin had to be washed in warm soap suds to remove all traces of stain.

Cold water removed coffee stains from all of the dry cleaned untreated fabrics with the exception of poplin I (which required hot water). All of the dry cleaned treated fabrics had to be washed in warm soap suds to remove the coffee stains.

The treated fabrics differed, however, in that the grape juice stain was removed from the organdy and broadcloth with cold water. The poplin required the hot water rinse.

All visual traces of grape juice stain disappeared from the control of the untreated organdy and broadcloth by rinsing in first cold then hot water. But both poplin I and II had to be washed in soap suds. Even then the stains were stubborn. The broadcloth reacted the same as the organdy. The treated poplins had to be washed in warm soap suds. Grape juice was slightly more difficult to remove than coffee from all of the control fabrics except the organdy. Laundering did not reduce the stain resistance of the untreated fabrics but warm soap suds had to be used to remove the stains from the four dry cleaned untreated fabrics. The grape juice stain was removed from the dry cleaned untreated organdy by rinsing in cold water, from poplin I, by washing in soap suds, and traces remained on poplin II even after the warm soap suds washing process. The grape juice was removed from the "Zelan" treated organdy and broadcloth with cold water but the poplin required the hot water rinse. The stain did not penetrate the treated fabrics to as great an extent as it did the untreated fabrics, but the slight stains that developed were more difficult to remove from the treated fabric than the more distinct stains from the untreated ones. Laundering did not change the stain resistance of the treated fabrics but dry cleaning seemed to remove both "Zelan" and Aridex finishes.

Ink stains were not removed from any of the fabrics (treated, untreated, laundered or dry cleaned) by the methods previously used with the grape juice and coffee stains. The surface of the untreated fabrics was completely stained in the area of the falling liquid. The treated fabrics, in most instances, were stained severely only at spray points. Much of the stain was removed from the laundered and dry cleaned portions of the treated fabrics by washing in warm soap suds. Complete removal of ink stains was achieved for all portions, control, dry cleaned and laundered of both treated and untreated fabrics in both finishes only by a commercial laundry. However, the penetration of the ink into the fabric was not as complete in the treated as the untreated fabrics. The stain was more intense in the Aridex than in the "Zelan" treated fabrics.

SUMMARY

The purpose of this study was to ascertain the effects of certain finishes on the moisture repellent qualities and stain resistance of selected fabrics; and to determine the extent to which these finishes are permanent to laundering and dry cleaning.

The "Zelan" and Aridex finished fabrics showed equal repellance to water and were similar in their resistance to stains but varied greatly in their permanence to laundering and dry cleaning.

"Zelan" finished fabrics showed a high degree of repellency which was not noticeably decreased by 10 launderings. However, this finish showed a marked decrease in resistance to moisture and stains after five dry cleanings.

Although the breaking strength of this fabric was slightly reduced by the "Zelan" finish the wearing quality was increased as shown by abrasion tests.

The "Zelan" treated fabrics had a high resistance to stain penetration with the exception of ink. The stains were easily removed in the control and laundered specimens, but were less easily removed from the dry cleaned portions.

Aridex treated fabrics showed no resistance to water after 10 launderings and five dry cleanings. The finish increased the wearing quality only slightly.

Stains caused by coffee and grape juice were removed from the treated fabrics by rinsing in cold water. All traces were removed by sponging in warm soap suds.

Stains in the dry cleaned Aridex treated fabric were the most difficult to remove. All fabrics subjected to ink had to be sent to the commercial laundry for removal of stains.

ACKNOWLEDGMENT

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