EFFECT OF OZONE AND LIGHT ON CURTAIN MARQUISETTES OF DIFFERENT FIBER CONTENT

By

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EFFECT OF OZONE AND LIGHT ON CURTAIN MARQUISETTES

OF DIFFERENT FIBER CONTENT

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CHAPTER I

INTRODUCTION

Pollution of the atmosphere is becoming a growing threat of national proportion. It can corrode metal, rot wood, disintegrate stone, discolor paint, and dissolve clothing. Its effect upon plant and animal life is still being determined (9).

The author developed an interest in this problem while living in the Los Angeles area. It was observed that nylon stockings appeared to have a shorter life span in that environment than they had in Southeastern Nebraska. Ozone is one of the chief components of atmospheric pollution in the Los Angeles area. Because an ozone atmosphere can be produced within a test chamber, laboratory investigations of fiber deterioration in such an atmosphere are feasible.

This study is primarily concerned with the effects of ozone and light, principally ultraviolet, upon the deterioration of nylon, Dacron, cotton, acetate, and Fiberglas marquisette curtain fabrics exposed in a test chamber, especially designed for the experiment.

The objectives of this investigation were to:

1. Design a test chamber in which temperature, humidity, and ozone levels could be maintained within a reasonable range.
2. Determine the change in breaking strength and whiteness at various exposure periods in the test chamber.

3. Evaluate the effectiveness of the test chamber and the methods and procedures used in the investigation.

CHAPTER II

REVIEW OF LITERATURE

Pollution of the atmosphere has been considered a contributor to the diseases of man since the First Century (12). Industrialization since World War II and an increase in automobile exhaust have prompted renewed and more intensified interest in the effect of air pollution upon every aspect of our health, food, and possessions.[1]

The study of the effect of atmospheric pollutants upon fabrics has been limited in scope. Complaints from consumers have been in the area of color fading damage, and the American Association of Textile Chemists and Colorists has been concerned with test methods able to predict dye service performance. The atmospheric contaminants under study by the American Association of Textile Chemists and Colorists (17) include oxides of nitrogen, ozone, sulfur dioxide, and the products of hydrocarbon combustion.

Dorée and Healey (6) have shown that dry ozone has little effect on dry cellulose, but ozone in the presence of water strongly attacks cellulose.

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[1]Cf. Howard R. Lewis, "With Every Breath You Take," Reader's Digest. LXXXVII (September, 1965), p. 68. President Lyndon B. Johnson has said, "Pollution of the air threatens the health and welfare of our citizens, diminishes the economic vitality of our nation, and mars and obscures the beauty of our cities, parks and open spaces. It is, therefore, important that we give high priority to efforts to achieve and maintain control of the many sources of air contamination. Neglect of this need today will only mean a more serious problem tomorrow."

In outdoor exposure tests of cotton yarns in industrial Leeds, England, Race (14) found greater breaking strength loss in the winter than in the summer. More daylight and direct sunlight were present in the summer, but more sulfuric acid from heating was present in the winter. Fog was a factor in the winter months which kept the acid concentrated near its place of origin. He stated that three natural agents: air, sunlight, and atmospheric moisture were important in weathering of cellulose.

The National Research Council Prevention of Deterioration Center (13) also found evidence that the greater the amount of moisture, oxygen, ozone, and heat, the faster and more severe would be the effect of irradiation by light.

The American Association of Textile Chemists and Colorists (20) specifically recommends the use of higher humidities in test procedures involving the fading of dyes on cellulosics and nylons exposed to atmospheric contamination and ozone. This recommendation resulted from dye fading comparison studies done in dry and non-polluted Phoenix, Arizona, moist Sarasota, Florida (ozone present), smoggy Los Angeles (a high ozone, low sulfur dioxide area), and industrial Chicago (low ozone, greater sulfur dioxide area).

Laboratory experiments by Bogaty, Campbell and Appel (3) confirmed the importance of humidity in deterioration of cellulose. Ozone occurring in the air at the earth's surface up to 0.06 parts per million deteriorated wet cotton print cloth, although this deterioration was considered slight in comparison with the effects of light, heat, and microorganisms. When the dry cloth was exposed to ozone, it underwent little or no change in breaking strength. Fifty to 60 days of ideal exposure conditions were necessary to decrease the breaking strength of cotton duck by 20 percent. It was concluded that the contribution of atmospheric ozone to weather deterioration of the cotton fabric was relatively small.

Salvin (17) reported that it is not known if fibers are more receptive to ozone because of water swelling or if ozone is present in the water film in a more concentrated form. High humidities, 85-95 percent, were used for the accelerated laboratory tests.

The American Association of Textile Chemists and Colorists has a test method for Colorfastness to Ozone in the Atmosphere which uses a metal ozone exposure chamber with two 4-watt ozone lamps to generate ozone for a specified cycle. Standard blue acetate test ribbon and control ribbon are specially dyed to be ozone sensitive only. One cycle of fading of the test ribbon approximates six months exposure to ozone without sunlight in a moderate ozone area. The chamber is not sealed, and ventilation is an important factor in its operation. The test ribbon fades faster in an air pollution area, such as in Los Angeles. The color change of the ozone sensitive ribbons is evaluated by use of an International Geometric Gray Scale, and the number of cycles run by the ozone exposure chamber is recorded (5). Humidity is an important factor in this test procedure. Dyes on acetate, triacetate, and polyester fibers show change at low humidities. Rayon and cotton show greatest change at 75-85 percent relative humidity (16).

Salvin (19) stated in a letter to the author that the standard of fading ozone ribbon is a measurement of the fading in an area of moderate ozone concentration over a period of 6 months.

Light is a form of radiation which travels in waves. Not all wavelengths of energy from the sun reach the earth, because wavelengths shorter than 2700 angstroms to 3000 angstroms are absorbed by the ozone in the upper atmosphere (13, 15). Ordinary clear glass absorbs light up to 3200 angstroms and usually higher wavelengths. This range excludes most of the ultraviolet rays which are responsible for much fabric damage. According to Smith (21), the ultraviolet wavelength range is from 4000 angstroms up to 100 angstroms. The American Society for Testing Materials (2) stated that good grade, clear, flat-drawn sheet glass, single strength (2 to 2.5 millimicrons thick), free of imperfections, is to be used when enclosing fabrics under glass in chambers for sunlight exposures. This quality of glass absorbs radiation below wavelengths of 310 millimicrons and transmits rays up to 90 percent at 370 millimicrons to 380 millimicrons.[1] Glass meeting these specifications transmits 85 percent total radiation which includes a minimum of 77 percent ultraviolet and 90 percent average daylight (Illuminant C).[2]

Robinson and Reeves (15) stated that dyeing accelerates cotton degradation in the presence of light, and that mercerized cotton shows less deterioration as measured in breaking strength than the unmercerized cotton.

Research at the Naval Clothing Depot in Brooklyn has shown that sunlight and intense atmospheric pollution are the most potent factors of weathering (10).

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[1]An angstrom unit, abbreviated A, is 1/10 of a millimicron, abbreviated mμ. One thousandth of one millionth of a meter equals one billionth of a meter and is called a millimicron (mμ). Ball, Victoria Kloss. The Art of Interior Design. New York: The Macmillan Company, (1960), 96.

[2]Libbey-Owens-Ford Flat-Drawn Sheet Glass, single strength, quality B, and Pittsburgh Pennvernon Sheet Glass, single strength, quality B, meet these specifications.

Appleby (1) discussed artificial sources of radiation including the General Electric S-1 sunlamp. Its main disadvantage is a low output of light, necessitating longer exposures to produce photochemical changes.

The American Association of Textile Chemists and Colorists has developed eight Blue Wool Lightfastness Standards (4) for use in assessing colorfastness of fabrics to daylight and sunlight. The eight wool standards range from Number L2 (poor lightfastness) to Number L9 (exceptional lightfastness with twice the lightfastness of Number L8). These standards are compared with the International Geometric Gray Scale (8) to assess difference in color between exposed and unexposed standards. Each higher numbered standard is approximately twice as fast to light as the preceding standard.

Fabric construction plays a role in the deterioration of yarn by light waves. Coarse yarns are less affected by light than finer yarns, as the outside protects the inside (7). Net constructions are degraded six times as fast as closely woven repp constructions (22).

CHAPTER III

MATERIALS AND METHODS

Because of the complexity of obtaining and controlling other atmospheric contaminants, only ozone was selected for use in a test chamber especially designed for this experiment. Other factors considered in the design of the test chamber were humidity, air circulation, ultraviolet light source, glass admitting these light rays, distribution of samples within the chamber and their exposure to the elements, and the measurements of light, ozone, humidity, and temperature.

Test Chamber

The chamber consisted of a sealed-lid chamber constructed from pine. The front and back sides of the chamber each held two 30 inch x 30 inch single strength, quality B window panes (left side and right side, front and back) which slid into place along grooves in the chamber sides and center. The glass panes could be completely removed through the top lid opening for ease in placing or removing fabric samples. A fan[1] for circulating the air and ozone was placed in the center in the bottom of the chamber. An aluminum fan baffle kept the direct force of the fan from

[1]Fan Motor (Unidirectional Motor, 1725 RPM), Lafayette Catalog Number 32G1601. Fan Blade (3 inch Cooling Fan), Lafayette Catalog Number 32G1611. Lafayette Radio Electronics Corporation; 111 Jericho Turnpike; Syosset, Long Island, New York; 11791.

blowing fabric samples. At opposite ends at the bottom of the chamber was an enclosed ozone producing G4511 bulb.[2] These bulbs were enclosed as a protective measure against rays from the bulbs. Vents in the bulb enclosure allowed the ozone to escape into the chamber. These ozone bulbs were wired in a ballast arrangement.

Hygrometers[3] were hung at opposite ends of the test chamber on opposite sides of the sample rack. Each hygrometer bulb was shielded from the RS R-40 bulb by a two-inch square piece of black construction paper taped to the side of the hygrometer.

Containers of water were placed in the bottom of the chamber to increase humidity. These containers were filled daily with 0.1% benzoic acid solution. The 0.1% benzoic solution was used instead of distilled water to reduce possible microbiological growth in the water. This solution does not appreciably affect surface tension (11).

Two General Electric RS R-40 bulbs[4] were used as the source of light. Each was mounted on a stand, which was located so that a bulb was centered in front of each 30 inch x 30 inch glass pane and at a distance of 36 inches from the pane. This distance of the lamp bulb

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[2]G4511 lamp (prior designation: OZ4S11), 4 watts, intermediate base, overall length of 2 1/4 inches, 6000 approximate hours life. 89G504 ballast, 110-125 volt a-c circuit, for use with 1, 2, or 3 G4S11 lamps. (Ballast size: 3 1/16 inches x 1 13/16 inches x 1 1/4 inches, weight 3/4 pound, watts loss: 7.5, power factor: 35%.) <u>General Electric Lamp Letter</u>, publication number 59-87, July 10, 1959.

[3]Hygrometer ("Slide Rule Hygrometer"), Lafayette Catalog Number 99G9006. Lafayette Radio Electronics Corporation; 111 Jericho Turnpike; Syosset, Long Island, New York; 11791.

[4]RS R-40 bulb (Reflector Sunlamp - I.F.), 275 watts, medium base, 110-125 volts, maximum overall length 7 inches, 1000 approximate hours life. <u>General Electric Large Lamp Catalog</u>, p. 67.

from the area to be covered was recommended by the instruction booklet accompanying the bulbs.

Four rows of wire were strung through the test chamber in order to hang the samples one-deep without their edges touching.

Behind the samples was a wire hanger positioned through the center post of the chamber with a hook on each end for the lightfastness standards.[5] Each RS R-40 lamp was tested for uniformity in terms of fading of the standards. Also on the wire in each half of the test chamber was placed a one-half inch wide strip of ozone-sensitive acetate ribbon,[6] suspended in a black construction paper open-end tube. Shielding was to prevent light striking the ribbons and yet allow accessibility of the strips to chamber atmosphere. An International Geometric Gray Scale[7] was used to evaluate change in color of the ozone test ribbon after each 9-day exposure period. A new set of ozone ribbons replaced the old at each 9-day exposure period.

A sling psychrometer was used to measure the temperature and humidity of the room surrounding the test chamber.

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[5] American Association of Textile Chemists and Colorists blue wool lightfastness standards. Supplier: American Association of Textile Chemists and Colorists; Research Triangle Park; Box 886; Durham, North Carolina; 27702.

[6] American Association of Textile Chemists and Colorists Ozone Fading Unit (Control Sample and Standard of Fading Number 109). Supplier: Testfabrics, Incorporated; 55 Vandam Street; New York, New York; 10013.

[7] International Geometric Gray Scale for Evaluating Change In Color (ISO Recommendation R105, Part 2). Supplier: American Association of Textile Chemists and Colorists; Research Triangle Park; Box 886; Durham, North Carolina; 27702.

Figure 1. Test Chamber

Fabrics

The fabrics chosen were white curtain marquisettes. Curtains receive maximum exposure to the atmosphere prevailing within a building, and they often receive maximum exposure to sunlight. Deterioration may be readily detected in the filling direction of marquisette because of the low filling strength as compared with warp strength.

The fabrics were of nylon, Dacron, cotton, acetate, and Fiberglas. Two curtain panels of each fiber, except cotton, were used. The cotton fabric was from a continuous yardage.

TABLE I

DESCRIPTIVE ANALYSIS OF THE FABRICS

Fabric	Yarn Number (Tex System)	Yarn Number Equivalents (System Indicated)	Yarns per Inch Warp	Yarns per Inch Filling
nylon	9.1	82 (Denier)	52	28
Dacron	9.0	81 (Denier)	58	36
cotton	13.0	45 (Cotton)	52	26
acetate	17.8	161 (Denier)	44	28
Fiberglas	36.2	137 (100 yd. lengths/lb.)	42	25

Experimental Procedure

Sampling

A statistician was consulted before samples were cut, and his suggestions were followed in setting up the experiment. A second set of curtain panels was used for the second experiment (with the exception of cotton which was available by the yard only). Numbers were assigned at random to the samples when cut from the curtain panel according to test chamber side (left or right), wire row in the chamber, and slot position within the row. A diagram of row and slot was made of each side of the test chamber. Fiber number and exposure period were assigned at random to the slots. Filling direction only was used in samples for determination of breaking strength. No two samples had the same filling yarn in common. Thirty-six samples were cut from each of the 10 curtain panels for a total of 360 samples.

Exposure of Fabric

The complete experiment was planned in replicate, hereafter referred to as Experiment I and Experiment II. Each experiment ran for a total of 45 days exposure in the test chamber. The exposure periods for each experiment were 0, 9, 18, 27, 36, and 45 days. Each experiment required 180 samples (36 samples of each fabric). Thirty samples (6 samples of each fabric) comprised the 0-exposure group for each experiment. The 150 samples to be exposed were divided into two groups of 75 samples each. One group was exposed in the left side of the chamber and the other in the right side, hereafter referred to as left side and right side. These 75 samples were subdivided into 3 samples of each of the 5 fabrics for each of 5 exposure periods. Assignment of the 3 samples within each side of the test chamber was at random.

Ozone bulbs were on for 12 hours and off for the following 12 hours throughout both experiments. Ozone generator bulbs were turned on and off automatically by an electric appliance timer.[7] The RS R-40 light bulbs and fan were run continuously.

Testing

Every 9 days 3 samples of each fiber were removed from each side of the test chamber from a predetermined and randomly positioned (by drawing numbers from a box) chart of each test chamber side. The empty spaces upon the wire rack were filled with the same fiber content space fillers of the same size, and the test chamber continued to operate for the successive 9 day exposure period. Visual evaluation of whiteness was made with the samples placed at a 45° angle under an unshielded south window at 9:00 A. M. The samples from each exposure period were compared with their own control for a change in color (whiter or yellower) in terms of a rating scale (0 for no apparent change, 1 for a slight change, 2 for a noticeable change, and 3 for an obvious change).

Tests were made under standard conditions and according to procedures recommended by the American Society for Testing Materials (2). The raveled strip method was used for testing breaking strength. Masking tape was used to cover that part of the Fiberglas strip held in the clamp jaws, in order to prevent fabric slippage in the clamps. This method was less time-consuming than treating the edges of the fabric with an adhesive, and it worked well.

Analysis of Data

Data for the breaking strength were analyzed as a split plot and

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[7]Montgomery Ward Signature automatic continuous 24-hour timer switch, 1875 watts, 15 amps, 110-125 volts, a-c current, 6 foot cord, Number 83A545.

a double replicate design (left and right side of the chamber, and Experiment I and Experiment II). Evaluation of data on whiteness was by visual comparison of exposed samples with control samples.

CHAPTER IV

RESULTS

Evaluation of Test Chamber

Test Chamber

A record was kept of the temperature and relative humidity within the test chamber. The minimum, maximum, and overall mean for all temperature and humidity readings may be found in Table II. A record was kept of the room temperature and relative humidity during Experiment II, and these data, when compared with test chamber data, showed there was no relationship between the humidity in the room and the humidity within the test chamber. However, the temperature within the room and the temperature within the test chamber stayed within three degrees of one another. Differences as indicated in Table II apparently had no significant effect on deterioration.

The ozone-sensitive acetate ribbons in each side of the test chamber were replaced every 9-day exposure period. When compared with the International Geometric Gray Scale, all ozone ribbons faded to step 2 on the scale.

The blue wool lightfastness standards were observed throughout the two experiments in order to see if differences in light intensity existed between sides of the test chamber or between experiments as indicated by fading of the standards. There appeared to be no differences.

TABLE II

MINIMUM, MAXIMUM, AND MEAN TEMPERATURE AND HUMIDITY FOR EACH EXPOSURE PERIOD
EXPERIMENT I AND EXPERIMENT II

EXPERIMENT I								EXPERIMENT II							
Dates	Days in Exposure Period	Temperature in Degrees Fahrenheit			Relative Humidity in Percent			Dates	Days in Exposure Period	Temperature in Degrees Fahrenheit			Relative Humidity in Percent		
		min.	max.	mean*	min.	max.	mean*			min.	max.	mean*	min.	max.	mean*
June 25-July 4	0-9	84	91	88	62	79	72	Aug 24-Sept 2	0-9	85	93	90	63	71	67
July 4-July 13	9-18	85	91	89	65	77	71	Sept 2-Sept 11	9-18	85	92	89	64	78	69
July 13-July 22	18-27	87	92	90	63	72	66	Sept 11-Sept 20	18-27	85	94	90	58	79	66
July 22-July 31	27-36	85	92	89	57	69	64	Sept 20-Sept 29	27-36	78	85	82	63	75	69
July 31-Aug 9	36-45	84	92	89	54	66	60	Sept 29-Oct 8	36-45	80	85	82	61	84	74

*The mean of all readings taken.

Replication of the Experiment

Repetition of the entire experiment provided the opportunity to determine the degree of reliability of the data obtained and of the consistency in operation of the test chamber. Statistical analysis of data from both experiments gave no significant difference in the experiment replicate (Item A in Table III), which means that there was no significant difference between Experiment I and Experiment II. (See Table III for the analysis of variance and coding system used.) There was no significant difference between left and right sides of the test chamber (Item B in Table III). The error term used was Replicate by Side Error (AB in Table III). The F value used to test significance at the $\alpha = .05$ level for 1 degree of freedom in the numerator and 1 degree of freedom in the denominator was 161. All other sources of variation were tested using Error (RA, AC, RAC, ABC, RAB, RABC) with 58 degrees of freedom in the denominator.

Breaking Strength

Because of unequal variances, fabric breaking strength means were converted to Log_{10} in order that the fabrics might be compared. Tables of the original breaking strength means may be found in Appendix A.

Statistical analysis showed that the fabrics behaved significantly different at the 5 percent level. Breaking strength means for each exposure period were also significantly different at the 5 percent level. There was significant interaction in Time by Fabric (RC in Table III), showing that the fabrics behaved differently over time. Figures 2 and 3 show mean breaking strength for all fabrics, all exposure periods,

TABLE III

ANALYSIS OF VARIANCE - EXPERIMENT I AND EXPERIMENT II

Source of Variation	Degrees of Freedom	Sum of Squares	Mean Square	F
Total	359	33.2624	0.0927	
Experiment Replicate (A)	1	0.0061	0.0061	17.4261
Side of Test Chamber (B)	1	0.0018	0.0018	5.0256
Replicate x Side Error (AB)	1	0.0004	0.0004	
Fabric (R)	4	30.9533	7.7383	2125.9159**
Time (C)	5	0.7837	0.1567	43.0602**
Time x Fabric (RC)	20	1.0848	0.0542	14.9019**
Time in Fabric Nylon	5	1.7198	0.3440	94.4931**
Linear	1	0.0100	0.0100	2.7409
Quadratic	1	0.0018	0.0018	0.4819
Residual	3	1.7080	0.5693	156.4143**
Time in Fabric Dacron	5	0.0675	0.0135	3.7104**
Linear	1	0.0004	0.0004	0.1225
Quadratic	1	0.0000	0.0000	0.0003
Residual	3	0.0671	0.0224	6.1431**
Time in Fabric Cotton	5	0.0248	0.0050	1.3651
Linear	1	0.0002	0.0002	0.0448
Quadratic	1	0.0000	0.0000	0.0011
Residual	3	0.0247	0.0082	2.2599
Time in Fabric Acetate	5	0.0404	0.0081	2.2220
Linear	1	0.0003	0.0003	0.0755
Quadratic	1	0.0000	0.0000	0.0000
Residual	3	0.0402	0.0134	3.6780*
Time in Fabric Fiberglas	5	0.0170	0.0034	0.9341
Linear	1	0.0001	0.0001	0.0195
Quadratic	1	0.0000	0.0000	0.0019
Residual	3	0.0169	0.0056	1.5497
Time x Side (BC)	5	0.0029	0.0006	0.1667
Fabric x Side (RB)	4	0.0169	0.0042	1.1610
Fabric x Side x Time (RBC)	20	0.0215	0.0011	0.2951
Error (RA, AC, RAC, ABC, RAB, RABC)	58	0.2111	0.0036	
Samples in Replicate x Side x Time x Fabric	240	0.1821	0.0008	

*Significant at the 5% level
**Significant at the 1% level

Coding Used: (A) - Experiment Replicate (Experiment I versus Experiment II)
(B) - Side of Test Chamber (left side versus right side)
(C) - Exposure Time
(R) - Fabrics

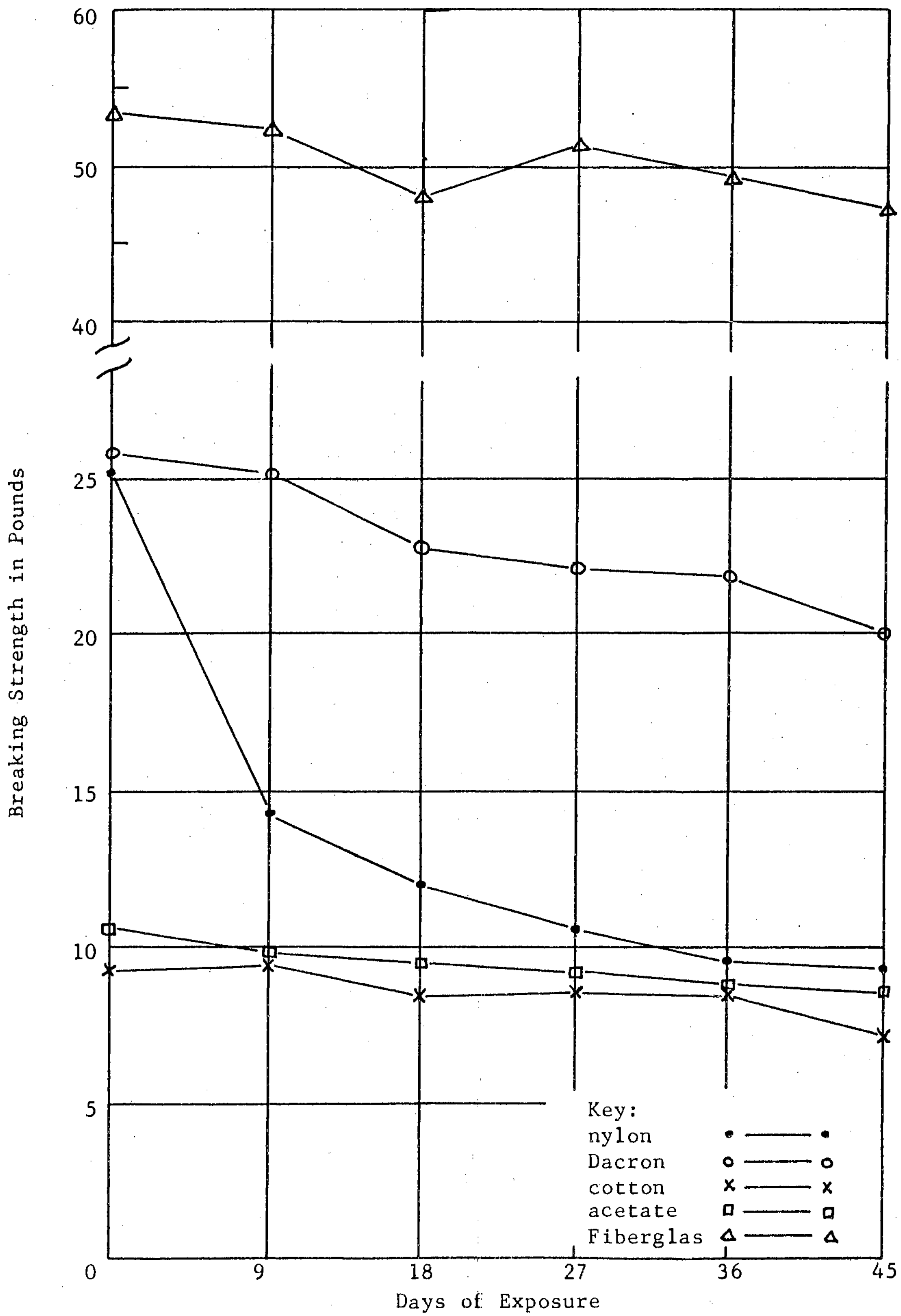

Figure 2. Graph of Breaking Strength Means for Experiment I, Left Side and Right Side Combined, All Exposures, All Fabrics.

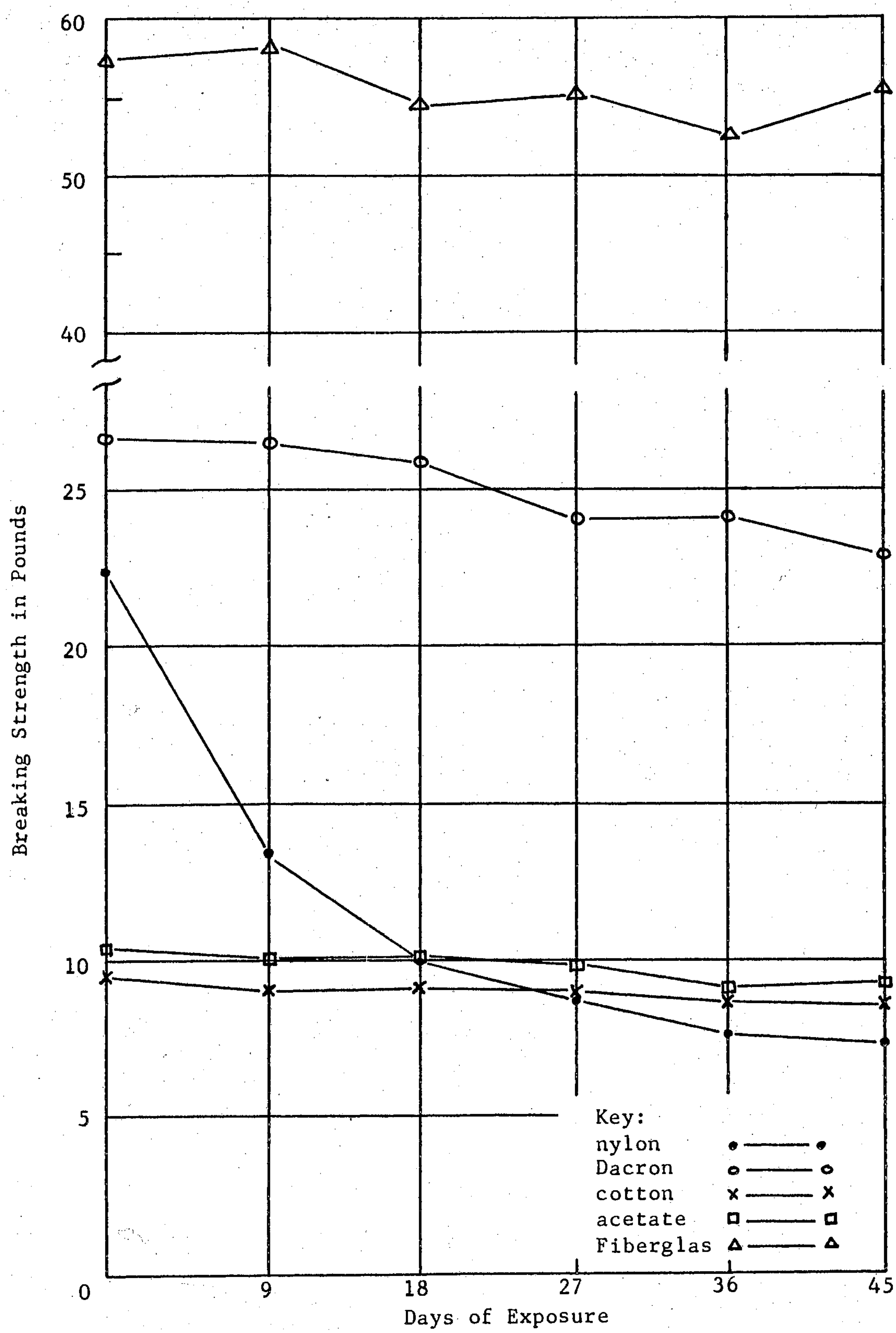

Figure 3. Graph of Breaking Strength Means for Experiment II, Left Side and Right Side Combined, All Exposures, All Fabrics.

test chamber sides combined; Experiment I and Experiment II. The interaction of Time by Fabric may be seen in Figure 3 in the nylon line crossing the acetate and cotton lines on the graph. If Figure 2 were superimposed upon Figure 3, one would see the interaction of Time by Fabric which was shown to be significant in the analysis of variance table. Because of this interaction, time in each fabric by itself was tested for significance in the analysis of variance table. (See Table III.) F values show that nylon and Dacron over time had significant deterioration. Acetate was not quite significant. There was much variation in the breaking strength data for Fiberglas for each exposure period. An analysis of variance for Fiberglas data indicated that the sample size of 6 (3 from each side of the test chamber) was not adequate.

Time in each fabric was further broken down into linear, quadratic, and residual in an attempt to describe the type of line which would be plotted from fabric means. It was found that a polynomial would give the best curve approximation.

Whiteness

Table IV shows the results from the visual comparison of each fabric with its own control sample. The control samples were of varying degrees of whiteness and were not compared with one another. The acetate control had a slight pink cast to it; the Fiberglas was gray-white; the cotton was yellow-white, and the Dacron and nylon were white-white. After each exposure period, two of the six samples of each fabric were compared with their control sample which gave two whiteness comparisons for each fabric. These two observations were called A and B in Table IV.

TABLE IV

WHITENESS: VISUAL COMPARISON OF THE CHANGE IN WHITENESS OF EACH OF THE FIVE MARQUISETTES AFTER EACH PERIOD OF EXPOSURE

EXPERIMENT I

Fiber	Exposure Period in Days: 9		18		27		36		45	
	Observation*: A	B	A	B	A	B	A	B	A	B
nylon	0	0	0	0	0	0	0	0	+1	+1
Dacron	0	0	0	0	0	0	0	0	+1	+1
cotton	0	0	0	0	0	0	+1	+1	+2	+2
acetate	-2	-2	-2	-2	+1	+1	+2	+2	+3	+3
Fiberglas	0	0	-1	-1	-1	-1	-1	-1	-1	-1

EXPERIMENT II

Fiber	Exposure Period in Days: 9		18		27		36		45	
	Observation*: A	B	A	B	A	B	A	B	A	B
nylon	0	0	0	0	0	0	0	0	+1	+1
Dacron	0	0	0	0	0	0	0	0	0	0
cotton	0	0	0	0	0	0	+1	+1	+2	+2
acetate	-2	-2	-2	-2	+2	+2	+3	+3	+3	+3
Fiberglas	0	0	-1	-1	-1	-1	-1	-1	-1	-1

*Key to Table: 0 = no change, 1 = trace, 2 = noticeable change, 3 = obvious change, + = yellower, - = whiter. A = First Observation, B = Second Observation

There was a slight difference between whiteness evaluation in Experiment I, as compared with Experiment II. Prior readings were not compared during the experiment in order to avoid bias. It is possible that the differences shown were differences in evaluation by the observer instead of differences in the fabric samples. The visual comparison gives only an estimate of change in whiteness. The fact that the fabrics were marquisettes made evaluation more difficult, as the background cloth was visible.

CHAPTER V

SUMMARY AND CONCLUSIONS

White nylon, Dacron, cotton, acetate, and Fiberglas marquisette curtain samples were exposed from 9 to 45 days to ozone and light, principally ultraviolet. A glass-enclosed test chamber was especially designed for the experiment. The entire experiment was replicated to provide a statistical analysis of data which would lead one to a better evaluation of the degree of reliability of the data obtained and of the consistency in operation of the test chamber.

At 9-day intervals over the total time of 45 days, fabric samples were drawn at random from the test chamber, and empty spaces were filled with fabric samples of the same fiber content. The samples which were removed every 9 days were tested for degree of whiteness by visual comparison and breaking strength by the American Society for Testing Materials raveled strip method.

The data were statistically analyzed as a double replicate, split plot design. There were no significant differences between left and right sides of the test chamber or between Experiment I and Experiment II.

Nylon and Dacron showed a significant loss of strength over time. Acetate did not quite have a significant loss of strength with time. Fiberglas variance was high and it was concluded that the Fiberglas sample size was not adequate for this experiment. Cotton did not have a significant decline in breaking strength over the exposure periods.

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APPENDIX A

APPENDIX TABLE I

BREAKING STRENGTH MEANS FOR EXPERIMENT I AND EXPERIMENT II COMBINED, LEFT SIDE AND RIGHT SIDE COMBINED, ALL EXPOSURES, ALL FABRICS

Fiber	Exposure Period in Days					
	0	9	18	27	36	45
	pounds					
nylon	23.8	13.9	11.0	9.7	8.8	8.6
Dacron	26.3	25.8	24.4	23.1	23.2	21.5
cotton	9.4	9.3	9.0	9.0	8.6	8.3
acetate	10.5	10.0	9.8	9.6	9.1	9.0
Fiberglas	55.3	55.5	51.4	53.5	50.8	51.8

APPENDIX TABLE II

BREAKING STRENGTH MEANS FOR EXPERIMENT I, EXPERIMENT II, LEFT SIDE AND RIGHT SIDE COMBINED, ALL EXPOSURES, ALL FABRICS

EXPERIMENT I

Fiber	Exposure Period in Days					
	0	9	18	27	36	45
	pounds					
nylon	25.1	14.4	12.0	10.6	9.7	9.5
Dacron	25.8	25.1	22.9	22.1	22.0	20.0
cotton	9.3	9.5	8.6	8.8	8.5	8.1
acetate	10.6	9.9	9.6	9.3	8.9	8.7
Fiberglas	53.4	52.3	48.4	51.5	49.2	47.8

EXPERIMENT II

Fiber	Exposure Period in Days					
	0	9	18	27	36	45
	pounds					
nylon	22.4	13.4	10.0	8.9	7.8	7.6
Dacron	26.7	26.6	25.9	24.1	24.2	23.0
cotton	9.6	9.1	9.3	9.2	8.8	8.6
acetate	10.3	10.1	10.1	9.9	9.3	9.2
Fiberglas	57.3	58.6	54.4	55.6	52.4	55.8

APPENDIX TABLE III

BREAKING STRENGTH MEANS FOR LEFT SIDE, RIGHT SIDE
ALL EXPOSURES, ALL FABRICS
EXPERIMENT I

LEFT SIDE OF TEST CHAMBER

Fiber	Exposure Period in Days					
	0	9	18	27	36	45
	pounds					
nylon	25.2	15.1	12.2	11.0	10.8	9.9
Dacron	25.6	25.6	22.4	21.4	22.7	19.8
cotton	9.3	9.6	8.8	9.3	8.2	8.5
acetate	10.6	9.8	9.4	9.4	8.9	8.6
Fiberglas	53.8	48.0	49.3	52.2	49.8	44.3

RIGHT SIDE OF TEST CHAMBER

Fiber	Exposure Period in Days					
	0	9	18	27	36	45
	pounds					
nylon	25.1	13.6	11.8	10.1	8.7	9.2
Dacron	26.0	24.5	23.4	22.8	21.4	20.2
cotton	9.2	9.4	8.5	8.3	8.7	7.6
acetate	10.7	10.1	9.8	9.2	8.8	8.8
Fiberglas	53.0	56.7	47.5	50.8	48.5	51.3

APPENDIX TABLE IV

BREAKING STRENGTH MEANS FOR LEFT SIDE, RIGHT SIDE
ALL EXPOSURES, ALL FABRICS
EXPERIMENT II

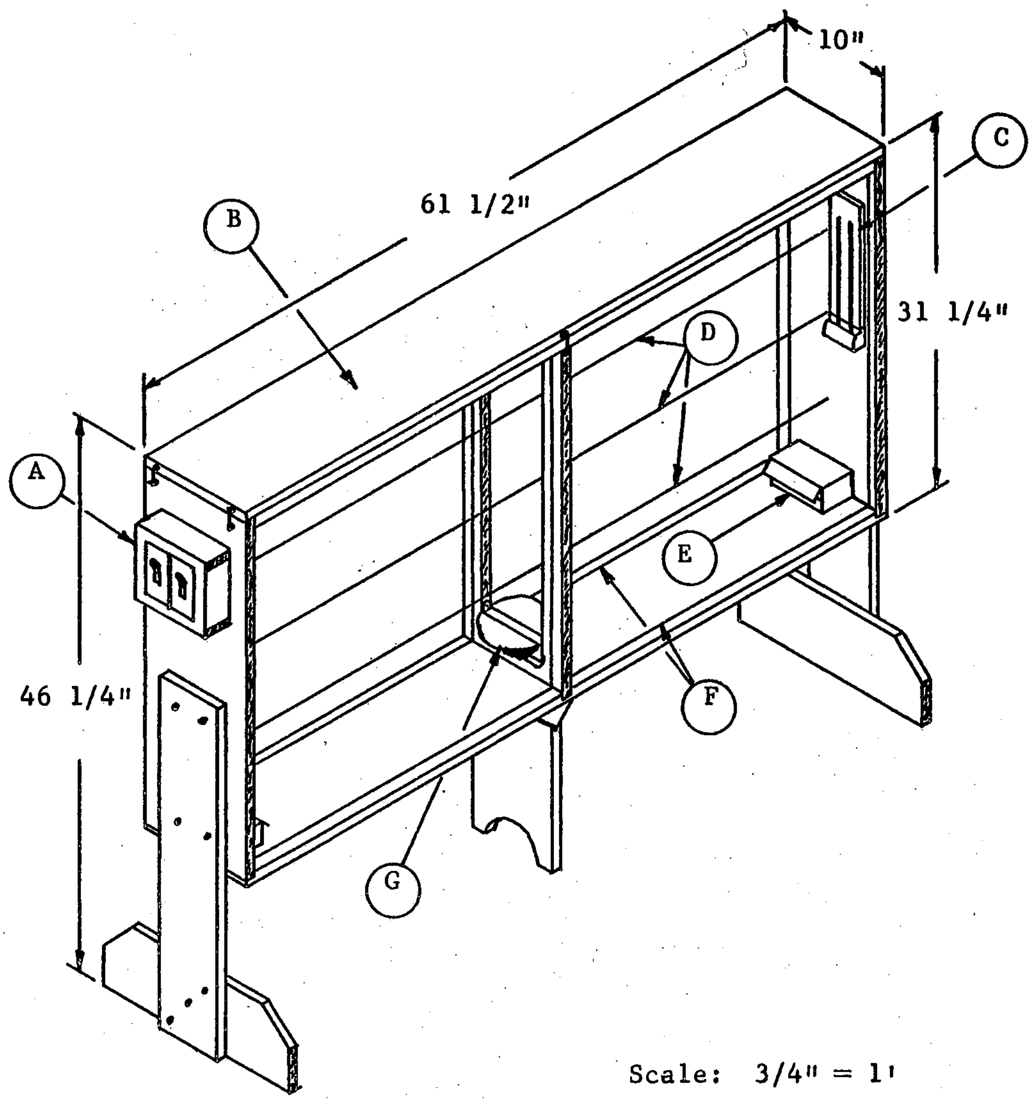
LEFT SIDE OF TEST CHAMBER

Fiber	Exposure Period in Days					
	0	9	18	27	36	45
	pounds					
nylon	22.7	13.9	10.6	9.1	7.6	7.8
Dacron	26.3	26.9	26.1	23.3	25.2	22.9
cotton	9.6	9.1	9.6	9.1	8.9	8.4
acetate	10.1	10.3	10.2	9.8	9.4	9.1
Fiberglas	58.2	57.3	50.7	57.8	52.2	54.3

RIGHT SIDE OF TEST CHAMBER

Fiber	Exposure Period in Days					
	0	9	18	27	36	45
	pounds					
nylon	22.1	13.0	9.4	8.8	8.1	7.4
Dacron	27.1	26.2	25.7	24.9	23.3	23.2
cotton	9.5	9.1	9.0	9.2	8.6	8.7
acetate	10.5	9.9	10.0	9.9	9.2	9.3
Fiberglas	56.3	59.8	58.2	53.3	52.7	57.3

APPENDIX B



TEST CHAMBER

KEY:

A. Switches for Fan and Ozone Generators
B. Removable Top (secured by 6 hooks and eyes)
C. Hygrometer (one at each end of chamber)
D. Wires for Samples
E. Ozone Generators (one at each end of chamber)
F. Grooves for Mounting Glass Panels
G. Electric Fan with Deflector Baffle

TEST CHAMBER CONSTRUCTION MATERIALS

Number Used	Description
2	1 inch x 10 inch x 10 feet pine lumber
4	30 inch x 30 inch single strength quality B glass panes
1	1 inch x 6 inch x 8 feet pine lumber
1	1 inch x 4 inch x 8 feet pine lumber
1	1 inch x 10 inch x 6 feet pine lumber
1	1/4 inch dowel (for chamber lid)
1	20 feet electrical wire
2	electrical wall switches
6	door hooks and eyes
2	electrical sockets for ozone bulbs
2	electrical sockets for S-1 lamps
1	1 quart varnish
1	2 square feet sheet aluminum

Miscellaneous

nails, screws, strap brackets, wood glue, rubber stripping and felt (to seal chamber)

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