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ACCELERATED AGING TEST FOR WEIGHTED SILK

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ABSTRACT

The rate at which silk, particularly weighted silk, will deteriorate on exposure to light, heat, and moist air cannot be predicted simply from the amount of weighting or other substances present on the silk. A laboratory test which will indicate the relative stability of silks is needed.

The aging, as revealed by changes in breaking strength, of a variety of silk and weighted-silk cloths when stored in the dark, when exposed to the daylight received through a north window (natural aging), or to the radiation from the glass-enclosed carbon-arc lamp under controlled conditions of temperature and relative humidity of the atmosphere (accelerated aging) was studied.

Data on the accelerated aging of some typical silk dress fabrics were obtained. An accelerated aging test is proposed.

CONTENTS

I. INTRODUCTION

It is well known that silk deteriorates when exposed to daylight, becoming weak and brittle, and that the rate of deterioration depends not only upon the nature of the radiation and of the atmosphere about the silk, but also upon the substances present on it. Sizing, weighting, and finishing materials and even traces of acids, alkalies, salts, soaps, and oils left on the silk after processing, drycleaning, or laundering may influence the rate of deterioration materially. Some of these substances increase the rate, others decrease it. Therefore the extent of the deterioration to be expected in a given time cannot be predicted simply from the *amount* of weighting or other substances present in the silk.[1]

[1] References to some of the experimental work on the deterioration of silk which can be cited in support of these statements follow:

M. Furry and R. Edgar, *A study of weighted silk fabric*, J. Home Econ. **20**, 901–905 (1928).

M. H. Goldman, C. C. Hubbard, and C. W. Schoffstall, *Effect of drycleaning on silks.* Tech. Pap. BS **20**, 605–634 (1926) T322.

M. E. Griffith, *The breaking and bursting strengths of some weighted and unweighted silk fabrics after exposure to light*, Ohio Agr. Expt. Sta. Bimonthly Bul. 151, 145–148 (1931).

M. Harris, *Photochemical decomposition of silk*, BS J. Research **13**, 151–155 (1934) RP697.

M. Harris and D. A. Jessup, *The effect of* pH *on the photochemical decomposition of silk*, BS J. Research **7**, 1179–1184 (1931) RP395.

K. Homolka, *Behandlung der Seide, um ihre Widerstandskraft gegen die Einwirkung des Lichtes zu erhöhen* Melliand Textilber. **6**, 584–585 (1925).

E. Ristenpart, *Die Wirkung des Lichtes auf erschwerte Seide*, Z. angew. Chem. **22**, 18–21 (1909).

N. M. Roberts and P. B. Mack, *A study of the effects of light and air on the physical properties of weighted and unweighted silks*, J. Home Econ. **24**, 151–165 (1932).

W. Stockhausen, *Beitrage zur Kenntnis der Seidenerschwerung*, Seide **34**, 445–448 (1929).

A. J. Turner, *The influence of atmospheric exposure on the properties of textiles*, J. Soc. Dyers Colourists **36**, 165–172 (1920).

L. Vignon, *Résistance de tissus aux intempéries et aux rayons ultraviolets*, Compt. rend. **170**, 1322–1324 (1920).

The deterioration can be accelerated in the laboratory by exposing the silk to radiation of relatively high intensity, rich in the shorter wave lengths and by increasing the temperature and relative humidity of the air about the silk. If the relative stability of silks in this accelerated aging is indicative of the relative stability under "natural" conditions, laboratory exposures can be utilized in the development of protective finishes, in the control of the finished product, and in the specification of silks with respect to relative stability. This last is of especial interest to distributors and users of weighted silks.

In order to compare natural and accelerated aging, a study was made of the changes in breaking strength of a variety of silk cloths when stored in the dark, when exposed to the daylight received through a north window, and when exposed to the radiation from the glass-enclosed carbon-arc lamp under controlled conditions of temperature and relative humidity of the atmosphere.[2] The results are given in this paper.

II. MATERIALS AND PROCEDURE

The silk cloths used for the preliminary experiments were all made from the same piece of commercially boiled-off cloth. Eight pieces of it were prepared in different ways in mills regularly engaged in this work. One piece was the original boiled-off silk. A second piece was dyed, "pure dye" in the figures. Six pieces were weighted to different extents and dyed. The series of eight pieces thus prepared is designated "dyed." A portion of each of the cloths of the dyed series was printed. A second portion of each of the cloths was "discharge printed."

The silk cloths used for the confirmatory experiments were similar to those of the dyed series, just described, but were made from a different piece of silk cloth. Two sets were prepared, the boiling-off, weighting, and finishing being done in two different mills.

Each sample of cloth for natural aging was divided into two pieces. One piece was stored in the dark in a clothes locker. The other was hung in one of the large factory-type windows of the cotton mill at the National Bureau of Standards. The samples were placed about four feet from the north windows and were exposed continuously. All samples in the preliminary tests were exposed simultaneously and all in the confirmatory tests simultaneously. The samples were frequently interchanged in position in order, as far as possible, to ensure comparability of exposure. The breaking strength of each sample in the warp direction was determined at intervals of time by the 1-inch strip method, averaging the results of three breaks. All samples were conditioned and tested in an atmosphere of 65-percent relative humidity having a temperature of 70° F (21° C).

The temperatures in the storage locker and in the window where the samples were exposed were observed three times daily during the

[2] Although the aging of silk cloth is not fully represented by changes in breaking strength, this seemed to be the simplest criterion to use for these exploratory studies. The changes in elongation at break of the fabrics were determined, but the results were somewhat erratic and are not reported.

first month and the last two weeks of the preliminary aging tests. The average temperature in the locker was 28° C and in the window 31° C during the first month. During the last two weeks the average temperature in the locker was 22° C and in the window 32° C. Thus the stored samples were at a lower temperature than the exposed.

The relative humidity of the atmosphere in the locker was that of the ordinary office room in which it was kept. The relative humidity of the atmosphere about the exposed samples was maintained at 70 to 75 percent during a considerable part of the time when the room was being used for spinning.

Accelerated aging was obtained by placing the samples in an insulated box having a glazed window, facing the glass-enclosed carbon-arc lamp of the Fade-Ometer.[3] The temperature of the air in the box was maintained at either 55 or 67° C by a thermostat, and the relative humidity was maintained at either 30 or 75 percent with saturated solutions of magnesium chloride and sodium chloride, respectively.[4] A motor-driven propeller kept the air in the box well mixed.

III. AGING OF SILK UNDER NATURAL CONDITIONS

The aging indicated by changes in breaking strength of silk cloth finished in 24 different ways, in dark storage and in the radiation received through a north window, is shown in figure 1. None of the fabrics decreased in strength more than 20 percent when stored in the dark for 240 days and the strength of the more heavily weighted silks did not change more than that of the silks containing less weighting or no weighting. The decrease in strength on exposure to light for 240 days varied from a little over 20 percent to over 95 percent, depending upon the finishing treatment the silk had received. In general, the discharge printed fabrics decreased in strength to a greater extent in a given time than the corresponding printed or dyed fabrics. The fabrics containing the greatest amounts of weighting did not decrease in strength as rapidly as did some of the fabrics containing less weighting. There was no consistent relationship between the decrease in breaking strength of these fabrics and the amount of nonfibrous materials in them.

IV. ACCELERATED AGING OF SILK

The changes in breaking strength of the 41-percent weighted, dyed silk referred to in figure 1, when exposed to the radiation of the glass-enclosed carbon-arc lamp under different conditions of intensity of radiation, relative humidity, and temperature of the atmosphere, are

[3] Manufactured by the Atlas Electric Devices Co., Chicago, Ill. Arc voltage 140, direct current, 13 amperes.
[4] Hugh M. Spencer, *Laboratory methods for maintaining constant humidity*, Int. Crit. Tables, 1, 67 (1926).

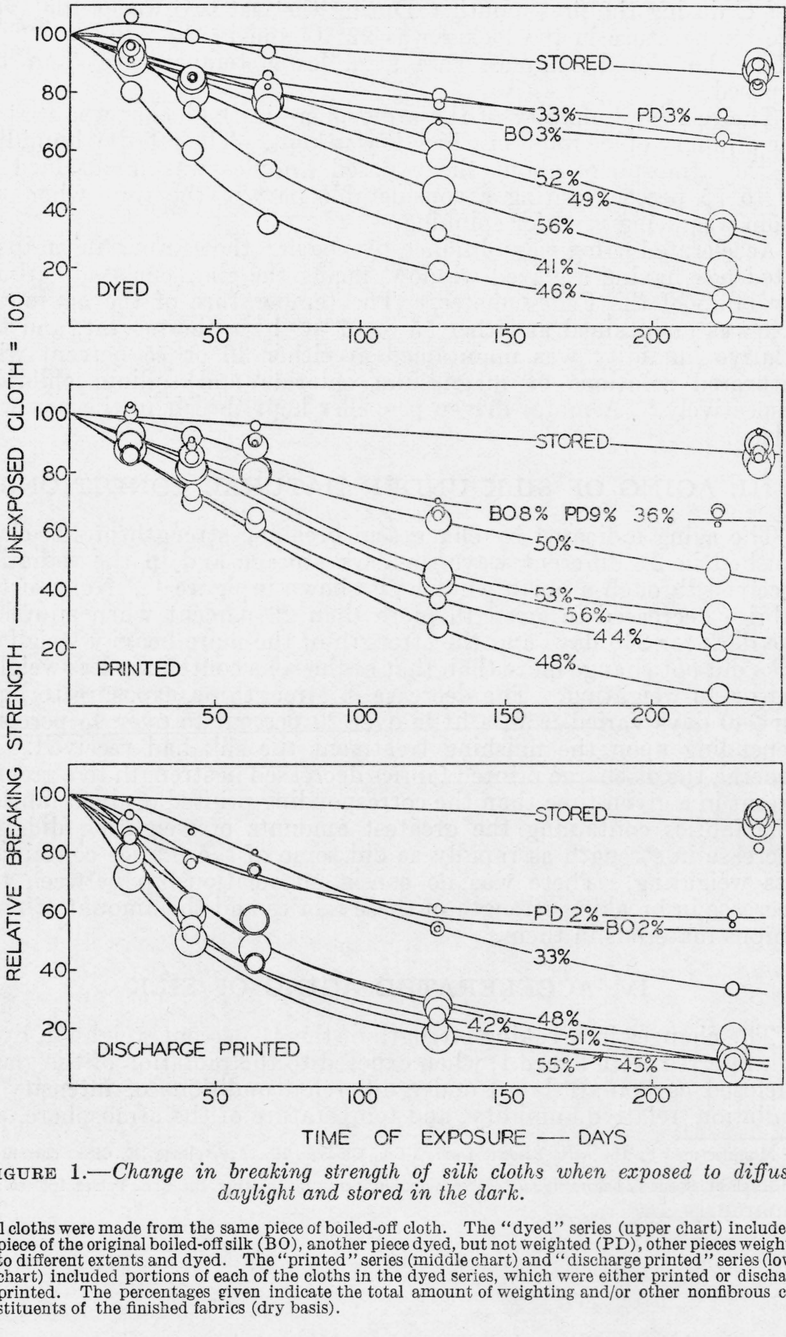

FIGURE 1.—*Change in breaking strength of silk cloths when exposed to diffused daylight and stored in the dark.*

All cloths were made from the same piece of boiled-off cloth. The "dyed" series (upper chart) included a piece of the original boiled-off silk (BO), another piece dyed, but not weighted (PD), other pieces weighted to different extents and dyed. The "printed" series (middle chart) and "discharge printed" series (lower chart) included portions of each of the cloths in the dyed series, which were either printed or discharge printed. The percentages given indicate the total amount of weighting and/or other nonfibrous constituents of the finished fabrics (dry basis).

shown in figure 2. The radiation received by the fabric passed through window glass ⅛ inch thick as well as the glass globe of the arc. The distance from arc to cloth was 15 inches for intensity 1.0 and 49 inches for intensity 0.1. The fabric required about twice as long an exposure at the lower intensity as at the higher to produce the same change in breaking strength. A change in relative humidity from 30 to 75 percent and in temperature from 55 to 67° C each materially decreased the time required to produce a given change in the breaking strength of the fabric. The breaking strength decreased about as much when the fabric was exposed for 20 hours at intensity 1, relative humidity 75 percent, and temperature 55° C as when it was exposed for 240 days in the north window.

V. COMPARISON OF NATURAL AND ACCELERATED AGING

The experiments just described were repeated with two new series of fabrics in order to confirm the results. The natural and accelerated aging of some of these fabrics are compared in figures 3 and 4.

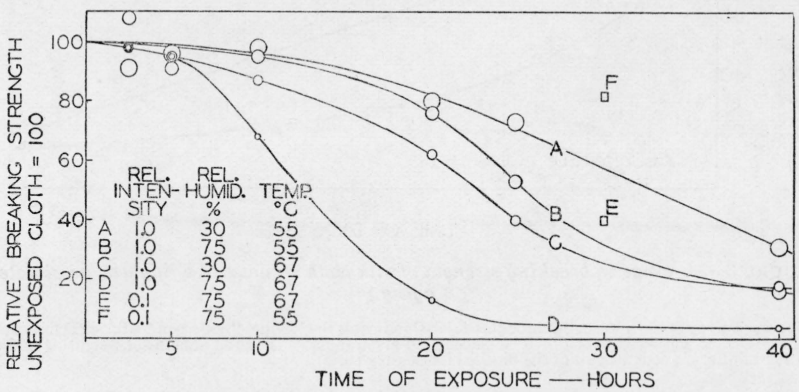

FIGURE 2.—*Change in breaking strength of weighted silk cloth when exposed to the radiation of the glass-enclosed carbon-arc lamp under controlled conditions of intensity of radiation, relative humidity and temperature of the atmosphere.*

The cloth was the dyed silk containing 41 percent weighting, figure 1.

The strengths of the boiled-off, pure dye, 51-, 53-, and 56-percent weighted silks finished in one mill (fig. 3) decreased very slowly and at about the same rate in the natural aging; the strength of the 42-percent weighted decreased distinctly faster, and that of the 38-percent weighted very much faster. Similar results were obtained with these fabrics in the accelerated aging test as shown in figure 3.

The strengths of the fabrics which were finished in a second mill did not decrease at a rapid rate in either the natural or the accelerated aging, except toward the end of the tests. Then the 45-percent weighted silk began to weaken rapidly in the natural aging and apparently also in the accelerated aging (fig. 4).

The results indicate general agreement in the behavior of silk fabrics in the natural aging and accelerated aging under the conditions specified when judged by the change in breaking strength. The relative behavior in the natural aging is reproduced in the accelerated aging as well as may be expected for a test of this kind.

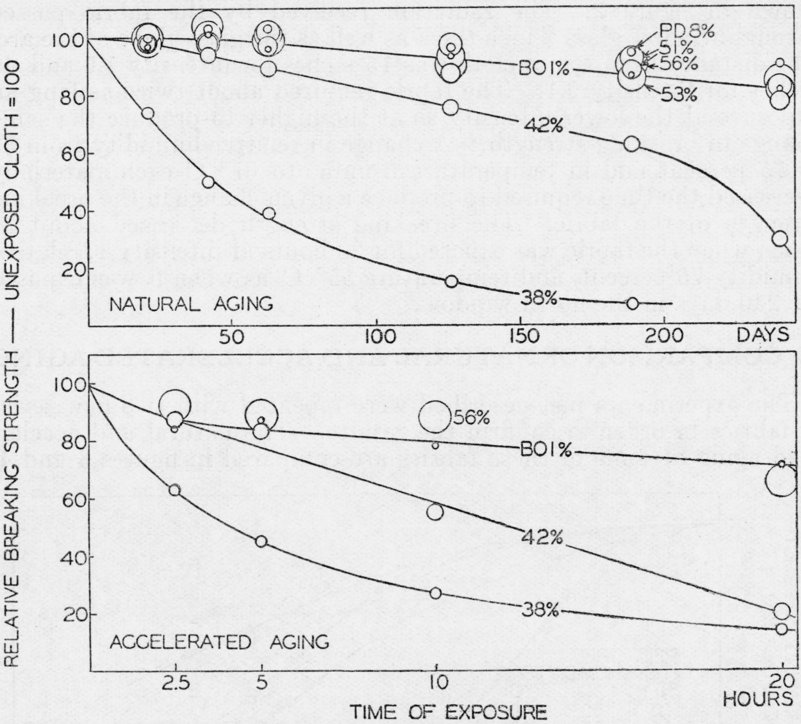

Figure 3.—*Change in breaking strength of silk cloth in natural aging and accelerated aging.*

The same basic silk cloth was used throughout. BO indicates the original "boiled-off" silk. PD indicates the dyed, but not weighted silk. The percentages given indicate the total amount of weighting and/or other nonfibrous constituents of the finished fabric (dry basis).

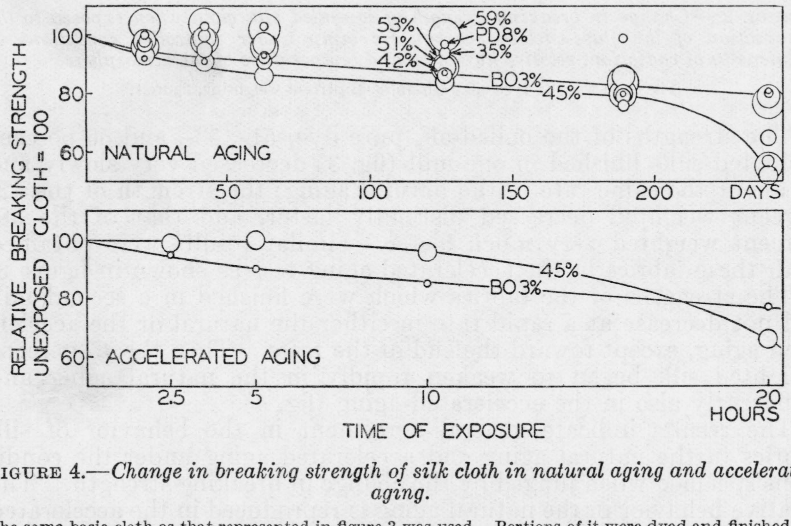

Figure 4.—*Change in breaking strength of silk cloth in natural aging and accelerated aging.*

The same basic cloth as that represented in figure 3 was used. Portions of it were dyed and finished by a different finishing plant than the one which finished the cloths of figure 3. The notation used in figure 3 applies to this figure as well.

VI. ACCELERATED AGING OF TYPICAL DRESS FABRICS

Through the cooperation of the American Home Economics Association and students of home economics in colleges in different parts of the country, samples taken from 23 silk dress fabrics purchased during the spring of 1930 for use in dressmaking projects were subjected to the accelerated aging test. Some of the results are given in figure 5.[5] The pure dye,[6] as well as the weighted silks, varied considerably in their relative stability in the test, judged by change in breaking strength. Nine out of the ten pure-dye silks in the lot had more than 50 percent of their original strength (warp or filling depending upon which showed greater change) after the 20-hour exposure. Only 4 of the 13 weighted silks had more than 50 percent of their original strength after exposure. The two silks containing about 35-percent weighting were among the four least stable of the

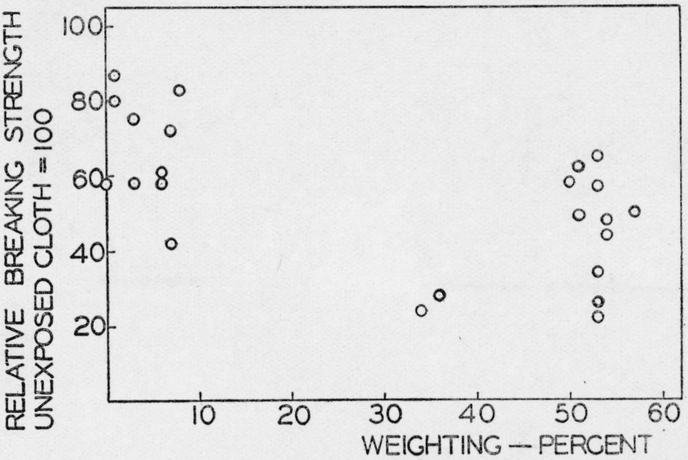

FIGURE 5.—*Typical silk dress fabrics—breaking strength after accelerated aging in relation to the amount of weighting or other nonfibrous materials present.*

weighted silks and were distinctly inferior to 8 weighted silks containing 50-percent weighting or more. The stability of neither pure dye nor weighted silks bore any relation to the weight per square yard. The most stable of the pure dye silks weighed 0.75 oz/yd ^{2} yard and the least stable 1.34 oz/yd ^{2}.

VII. PROPOSED ACCELERATED AGING TEST

The aging test outlined below is proposed on the basis of the results obtained in this study. It is hoped that, through the application of this test to a large number of fabrics of known serviceability by laboratories regularly engaged in testing silk fabrics, the relative stabiliy required for various uses can be worked out.

Specimens of the cloth suitable for warp and filling breaking-strength tests are exposed for 20 hours to the radiation from a glass-enclosed

[5] Detailed information concerning the constructions and properties of these fabrics is being incorporated by Dr. R. K. Worner of this Bureau in a report on the serviceability of dresses made from the fabrics.

[6] Silk containing less than 10 percent of nonfibrous materials. See Federal Trade Commission "Statement by the Commission, Trade Practice Conference, Silk Weighting" of June 18, 1932.

carbon-arc lamp, such as that of the Fade-Ometer, operated on direct current of approximately 13 amperes with the voltage across the arc approximately 140 volts. The distance from the specimens to the center of the arc is 15 inches. The specimens are enclosed in a cabinet glazed with window glass approximately ⅛ inch thick between the specimens and the arc. The air in the cabinet is maintained at 75 to 77 percent relative humidity and 63 to 67° C. The breaking strength of the cloth after exposure, expressed as a percentage of the breaking strength before exposure in the direction, warp, or filling, showing the greater change in strength, is taken to be indicative of the probable relative stability of the fabric with respect to exposure to light, heat, and moist air.

WASHINGTON, October 4, 1935.