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Letter
Circular
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STANDARD LIGHT-SENSITIVE PAPER FOR USE IN
TESTING TEXTILES FOR COLORFASTNESS TO LIGHT

GENERAL INFORMATION

Standard light-sensitive paper (NBS Standard Sample No. 700) and booklets of standard faded strips of this paper (NBS Standard Sample No. 701) are sold by the National Bureau of Standards for use in standardizing the dosage of radiant energy when testing textiles for colorfastness to light by exposure in commercial carbon-arc fading lamps. These lamps vary in fading rate from one to another and from time to time. The lack of duplicability in their performance must be taken into consideration in using them.

The paper is from a standardized lot produced in the National Bureau of Standards paper mill. It is colored with the direct azo dye, Benzo Azurine G, Colour Index No. 24140. The paper is in pieces 2-5/8 inches by 3-1/4 inches.

The booklets contain 6 strips of the paper 1-1/4 inches wide that have been faded by exposure in the National Bureau of Standards Master Lamp (1) in amounts corresponding to stated numbers of "Standard Fading Hours" of exposure between 7 and 25. Twenty "Standard Fading Hours" of exposure is equivalent in fading action to 20 clock hours of exposure in the well-known Atlas Electric Devices Company's FDA-R Fade-Ometer, based upon the average results of tests in one hundred and thirty of these lamps. It is also the exposure required to produce just "appreciable" fading of Lightfastness Standard L4 of the American Association of Textile Chemists and Colorists (2).

The paper and booklets make it possible to translate clock hours of exposure in lamps to "Standard Fading Hours" (SFH) and thus to express the dosage of radiant energy on a common basis. Instructions for ordering booklets and unexposed paper, directions for their use, and a brief discussion of sources of variations in fading tests follow.

HOW TO ORDER

Address orders to National Bureau of Standards, Standard Sample Unit (44.01/SS), Washington 25, D. C. In the order, state specifically the number of booklets and the number of packages of unexposed paper desired.

CALIBRATION OF LAMP

The paper may be used to check the performance of lamps from time to time in order to predict the number of clock hours of exposure that will be required to produce fading corresponding to a specified number of Standard Fading Hours. The more frequently such checks are made the greater will be the assurance that the lamp is performing satisfactorily.

The procedure follows: Mount a piece of the paper in a specimen holder of the lamp in the usual way (without backing) and place it in the lamp at the time it is started with a new set of carbons. Expose the paper continuously for 20 hours. Remove it and allow it to stand in the dark at room temperature for at least 2 hours in order for it to cool and to regain its normal moisture from the air. Trim off and discard the unexposed edges, as they may affect the judgment of the fading.

Compare the fading of the exposed paper with that of the standard faded strips in the booklet. To do this, hold the booklet in the left hand, allow the pages to flip open one after another, rear cover first, and slip the exposed paper under one standard faded strip after another, being careful to have the standard strip superimposed closely upon the exposed paper and the grain, that is the long dimension of the two papers, in the same direction. Make the comparison in the light from a daylight fluorescent lamp, or equivalent source, with illumination of 50 foot candles or more on the papers. The lamp should be parallel to the long edge of the paper and booklet. The incident light should be at an angle of 45° and line of sight should be perpendicular to the surface of the paper. Avoid touching the surfaces of the exposed paper and the standard strips with the fingers, as they are sensitive to moisture and soil easily.

From the comparison, estimate the exposure in Standard Fading Hours that would duplicate the fading of the test piece. Obtain a factor for converting clock hours of exposure in the machine to Standard Fading Hours. For example, if the paper exposed for 20 clock hours faded to an extent considered to fall half way between the 16 and 20 SFH strips in the booklet, i.e., 18 SFH, the factor would be $18/20$ or 0.9. Credit textiles exposed in the machine for a given number of clock hours with an exposure in Standard Fading Hours of 0.9 times the clock hours.

If the factor is greater than 1.1, the fading rate of the lamp is considered too high as it may produce anomalous results. The lamp should then be adjusted to a slower fading rate.

Exposures made on the 30-in. diameter sample rack of a Weather-ometer using No. 20 and No. 70 carbons, will probably be much lower than are those obtained on the 20-in. diameter rack of the NBS Master Lamp, and the above factors will not be applicable. Also, the necessity of turning the Weather-ometer spray off during exposures produces conditions which are not representative of normal Weather-ometer operating conditions.

Similarly, because of differences in spectral distribution and intensity of the carbon arc, exposures made with another type lamp such as a Xenon lamp, S-1 Sun lamp, or fluorescent lamp, would probably be quite different from the exposures of the Master Lamp, and the reflectance versus Standard Fading Hour curve shown in the attached figure would not apply. The paper has been calibrated only for carbon arc Fade-ometers.

USE OF PAPER IN TESTING

The lamp calibration outlined in the preceding paragraphs is a suitable basis for timing exposures in routine testing. For more precise testing, however, the dosage of radiant energy should be measured with the paper during each test, as the fading rate of a lamp may change from day to day and even during a test. The procedure is illustrated by the following directions for control of a 20-hour exposure.

Place the textile specimen and two (or more if desired) pieces of the paper in the lamp at the same time, side by side. Remove one of the papers from the lamp about 4 hours before the estimated end of the test, noting the time. Allow this paper to stand in the dark at room temperature for 2 hours; compare the fading with that of the standard faded strips; and obtain the factor for converting clock hours to SFH as already outlined. Use this factor in calculating the time of exposure for the textile under test. The piece of paper left in the lamp with the textile will have received the same radiant-energy exposure as the textile at the end of the test. The actual exposure in SFH at the end of the test will then be obtained by rating the fading of this paper with the standard faded strips in the booklet. The result can be used as evidence that the test was satisfactory or that it must be repeated.

For long exposures, a succession of papers will have to be used and the number of Standard Fading Hours shown by them added together to obtain the total exposure. In carrying out such tests the paper should be changed with each change of carbons.

FACTORS AFFECTING DUPLICABILITY IN FADING TESTS

The many factors that may affect the duplicability of results in testing textiles for colorfastness to light make such tests difficult to repeat. Some of the factors that the operator of a fading lamp should keep in mind include: density and spectral distribution of the incident radiant flux, the temperature and relative humidity of the air at the specimen, atmospheric contamination, method of mounting the specimen, and intermittent exposure. These factors affect the fading of the paper as well as textiles but the magnitude of the effects may not only be different for paper and textiles but also for different textiles. The relative rates of fading of different textiles and the paper will not necessarily change to the same degree with changes in these conditions.

Given the same current, voltage, other electrical operating conditions, and similar carbons, the radiant flux emitted by the carbon-arc fading lamp is assumed to be reasonably under control with respect to spectral distribution and amount. The use of the light-sensitive paper is intended to correct for moderate variations in radiant flux.

Commercial fading lamps usually provide some control of temperature and relative humidity of the air about the specimens. The method of the American Association of Textile Chemists and Colorists calls for exposure of specimens in filtered air that is humidified, with the temperature, measured with a special black panel thermometer facing the arc, of $145 \pm 5^{\circ} \text{F}$ ($63 \pm 3^{\circ} \text{C}$) recommended, but a temperature not to exceed 165°F (74°C) may be used if the black panel thermometer temperature is stated in the report of the results. (2)

In making preliminary comparisons of faded papers and standard faded strips, it is permissible to breathe on the faded paper momentarily to increase its moisture content. Final comparisons should be made as already indicated, or better, after conditioning the paper in the dark by exposure to air at 50% relative humidity overnight or longer.

The practice in some laboratories of mounting specimens on black or white cardboard or other backing has an effect on the fading especially of thin translucent specimens and therefore the backing used should be noted in reporting the results of tests. As already indicated, the light-sensitive paper should be exposed without backing as the SFH scale is based upon its use in this way. For strict control, the paper and textile should be put in the lamp at the same time and in comparable positions; for instance, both in the upper or lower row, and any vacant positions in the lamp should be filled with dummy specimens to reduce variations in air currents and reflections.

The paper and some textiles fade more in a given time if exposed intermittently than if exposed continuously, perhaps because of an increase in moisture content while the lamp is shut off and more rapid fading when it is turned on again. It is therefore desirable to begin tests with a fresh set of carbons in the lamp and to avoid shutdowns.

REFLECTANCE OF FADED PAPERS

Although the paper and booklets are designed for simple visual estimation of the fading, photometric measurements may be used. The latter are used regularly at the National Bureau of Standards in evaluating the faded strips that go into the booklets. A Hunter Multipurpose Reflectometer (3) with large aperture and amber filter (4) is used. The scale of the reflectometer is carefully calibrated against

porcelain enamel standards. The specimens are conditioned in the dark by exposure to air having a relative humidity of $50 \pm 4\%$ and temperature of $73.5 \pm 2^\circ \text{F}$ for not less than 16 hours. The reflectances of the papers in the booklets sold by the NBS fall within one-half Standard Fading Hour of that indicated in the booklet. The fading curve for light-sensitive paper Lot No. 2102 and limits of reflectance of the faded pieces in a typical booklet are shown in the attached figure. The papers may change in reflectance from exposure to air of lower or higher relative humidity, or temperature, light, soiling, and mishandling.

Paper from Lot No. 1554 was used in establishing the relation between "Standard Fading Hours" of exposure and reflectance and paper from this lot was distributed for several years. As this supply became exhausted a duplicate lot, No. 1589, was distributed. It was superseded by Lot No. 2101 which is now superseded by Lot No. 2102. Although these lots are essentially duplicate paper-mill runs they differ slightly in the fading in a given time of exposure. For this reason the paper from a given lot should be used only with booklets made from the same lot. When this is done, the indicated number of Standard Fading Hours in a test will be the same as would be obtained with any other lot of paper and its booklets.

Communications regarding the paper should be addressed to the National Bureau of Standards, Polymer Evaluation and Testing Section, Washington 25, D. C.

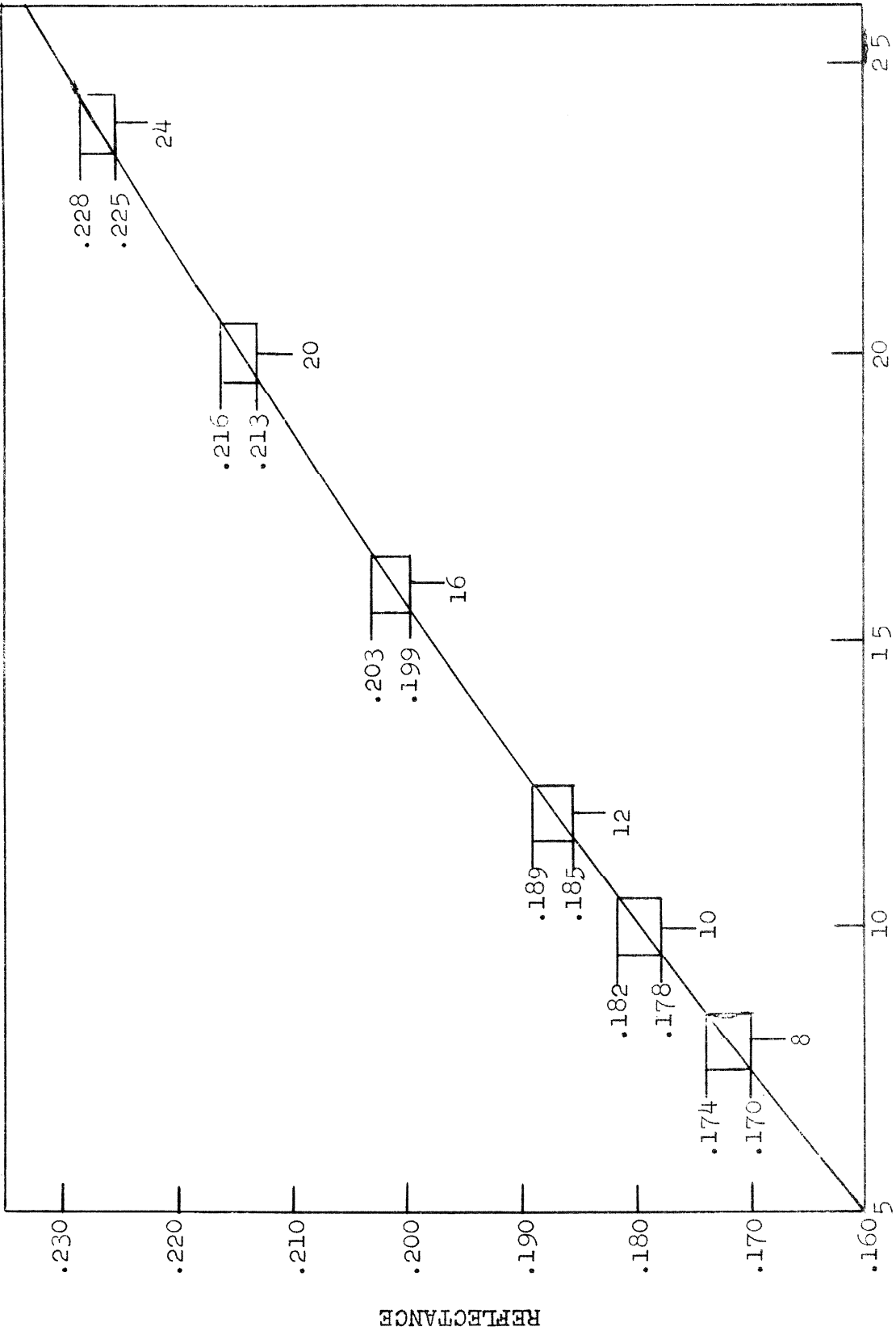
REFERENCES

- (1) The original Master Lamp described in NBS Research Paper RP1916, (J. Research NBS, Vol. 41, pp 169-177, 1948) has been replaced by an Atlas Electric Devices Company Fade-Ometer, type SMC-R with glass-enclosed arc operating on 15 to 17 amperes, 120-145 volts alternating current.
- (2) 1961 Technical Manual of the American Association of Textile Chemists and Colorists, Vol. XXXVII, National Headquarters, AATCC, P. O. Box 28, Lowell, Massachusetts.
- (3) A Multipurpose Photoelectric Reflectometer, by Richard S. Hunter. Journal of Research, National Bureau of Standards, Vol. 25, No. 5, 581-618 (1940). Research Paper RP1345.

- (4) Photoelectric Tristimulus Colorimetry with Three Filters, National Bureau of Standards Circular C429 (1942).

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USCOMM-NBS-DC



TIME OF EXPOSURE, STANDARD FADING HOURS
 LIGHT-SENSITIVE PAPER NO. 2102. STANDARD FADING CURVE