S. Department of Commerce
John T. Connor, Secretary
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Certificate of Calibration

Standard Reference Material 703

Light-Sensitive Plastic Chip

0.060 Inch

Two tentative curves for the fading of light-sensitive plastic plates (chips) are presented. These plates are made of poly (methyl methacrylate) containing the dye, Solvent Yellow 33, C. I. 47,000, and their thickness is nominally $\frac{1}{16}$ inch. They are to be used in the calibration of artificial fading and weathering apparatus. When used in such equipment, the radiation causes fading of the dye. The calibration of these plates was carried out in a carbon arc Fade-Ometer and is not directly transferable to other types of equipment.

The calibration of the plates was carried out against NBS Standard Reference Light Sensitive Paper No. 700a. This paper provided the definition of the Standard Fading Hour Unit (SFH). The calibration was carried out in the NBS master lamp, which is an Atlas Fading Device SMCR Type Carbon Arc Fade-Ometer. The diameter of the rack is 20 inches, and the samples to be exposed are mounted so that they are at the level of the arc. The lamp was operated so that the black panel temperature, as defined in AATCC Test Method 16A–1964, Appendix A, was 150° ±5 °F, and so that the relative humidity, as measured by wet- and dry-bulb thermometers at the air exit of the lamp was 30 ±5 percent.

The method of calibration was as follows: Exposures of plates were carried out for nominally 8, 16, 32, 64, and 128 SFH of exposure. For each of these times, nine plates were chosen at random, using a table of random numbers, from the lot of plates. The plate was broken in two, one-half saved for subsequent measurement of transmission and the other half mounted at random in nine of the nineteen positions of the NBS Standard Lamp. The holder for the plates was an Atlas CD–LSR holder modified to hold the plates. Its designation by Atlas Fading Devices Company is F–1375. The plates were exposed without backing in the lower position of the holder. The other ten positions of the lamp were occupied by Standard Fading Paper No. 700a. Since the fading curve of the paper is not defined beyond 25 SFH, in those runs which necessitated longer exposures than this, the lamp was stopped at appropriate times, the faded papers removed and measured, the plastic plates moved to other locations chosen at random and the empty positions filled with fresh papers. This was continued until the requisite number of SFH of exposures were achieved.

The thickness of each half chip was measured at 73.5 °F with a micrometer capable of estimation to 10^{-4} inch. The average of all the measurements was 0.0601 inch with a total spread of 0.0021 inch.

At the end of the exposure time the transmittance of the plastic plates was measured by the NBS Photometry and Colorimetry Section on the GE Recording Spectrophotometer according to ASTM Tentative Method D1920–64T. The slit width was approximately 10 nm (nanometers, 10^{-9} meter) of spectral width. Both unexposed and exposed halves of each plate were measured. To reduce polarization effects, two measurements were made on each plate. The orientation of the plate for these two measurements differed by a rotation of the plate by 90 degrees about the axis normal to the plane of the plate. The results of the measurements at these orientations were averaged.

The results for the averages of the nine unexposed and exposed halves for each exposure time are given in table 1. Transmittance is given both at the minimum which occurs nominally at 418 nm, and at 420 nm as recommended in ASTM Method D1920–64T. It is strongly recommended that the transmittance at the minimum be used since accurate calibration of the wavelength scale is then obviated.

All the results were subjected to statistical analysis. It was found empirically that the transmittance of the plates followed the equation.

$$\log T = a + b\,(\mathrm{SFH})^{1/2}. \tag{1}$$

Continued

TABLE 1

SFH of Exposure	Clock Hours of Exposure	Measurements at 418 nm minimum: Transmittance of exposed plate	σ[a]	Measurements at 420 nm: Transmittance of exposed plate	σ[a]
6.7	10.	0.4768	0.0021	0.4810	0.0023
15.8	18.1	.4999	.0029	.5041	.0030
33.9	39.9	.5390	.0051	.5409	.0052
67.6	76.0	.6050	.0039	.6056	.0043
123.6	140.0	.6576	.0028	.6591	.0031

[a] Standard deviation of an individual measurement.

Transmittance of unexposed plates.

at minimum at 418 nm:	0.3859	$\sigma = 0.0020$
at 420 nm:	0.3905	$\sigma = 0.0021$

TABLE 2

Fit to Equation: $\log T = a + b\ (\text{SFH})^{1/2}$

For transmittance measured at minimum at 418 nm

$\log T = -0.3657 + 0.01693\ (\text{SFH})^{1/2}$

Standard errors:

of a:	0.00181
of b:	0.000257
of an individual point:	0.0052
Coefficient of variation:	1.2%

For transmittance at 420 nm

$\log T = -0.3612 + 0.01654\ (\text{SFH})^{1/2}$

Standard errors:

of a:	0.00168
of b:	0.000239
of and individual point:	0.0049
Coefficient of variation:	1.1%

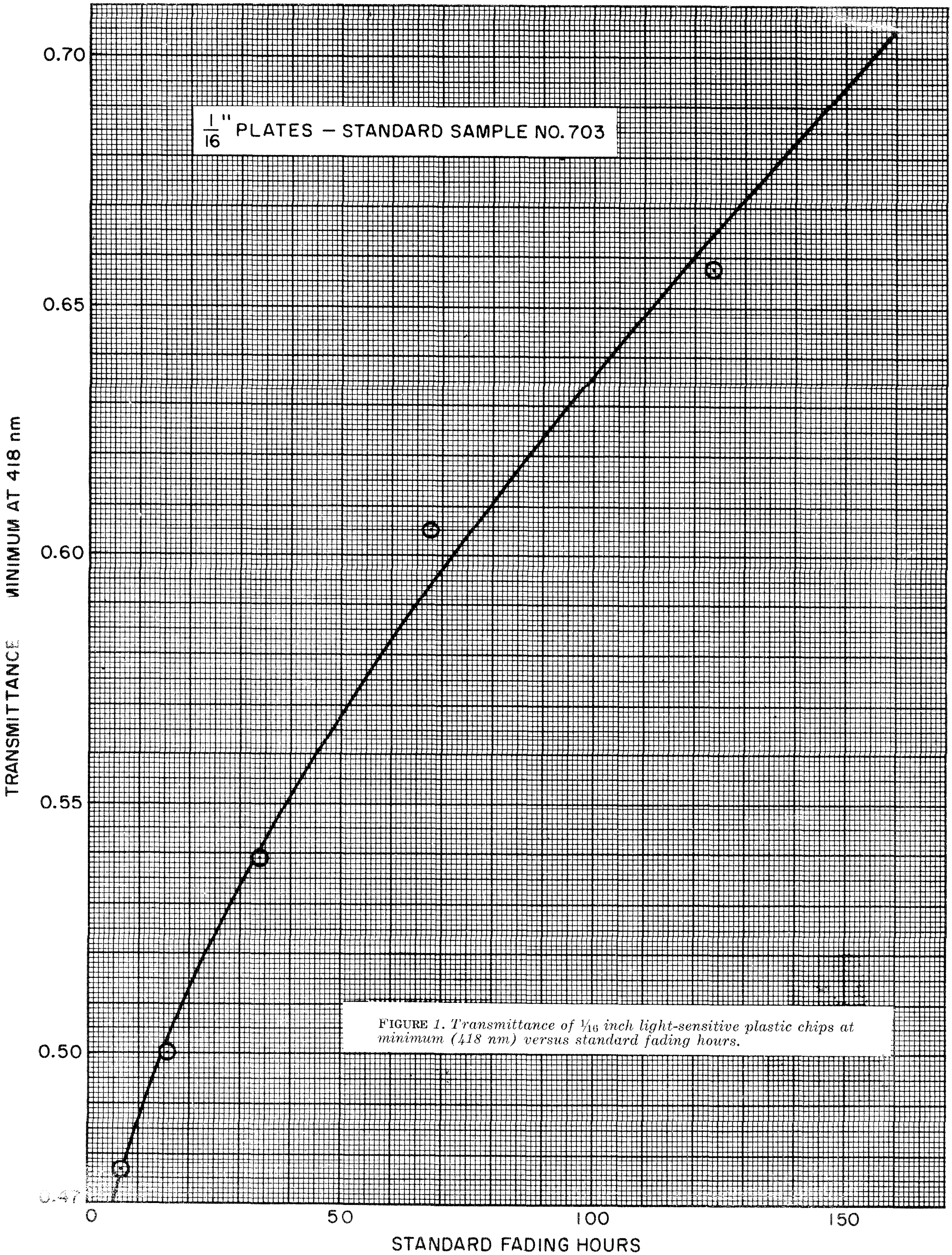

FIGURE 1. *Transmittance of 1/16 inch light-sensitive plastic chips at minimum (418 nm) versus standard fading hours.*

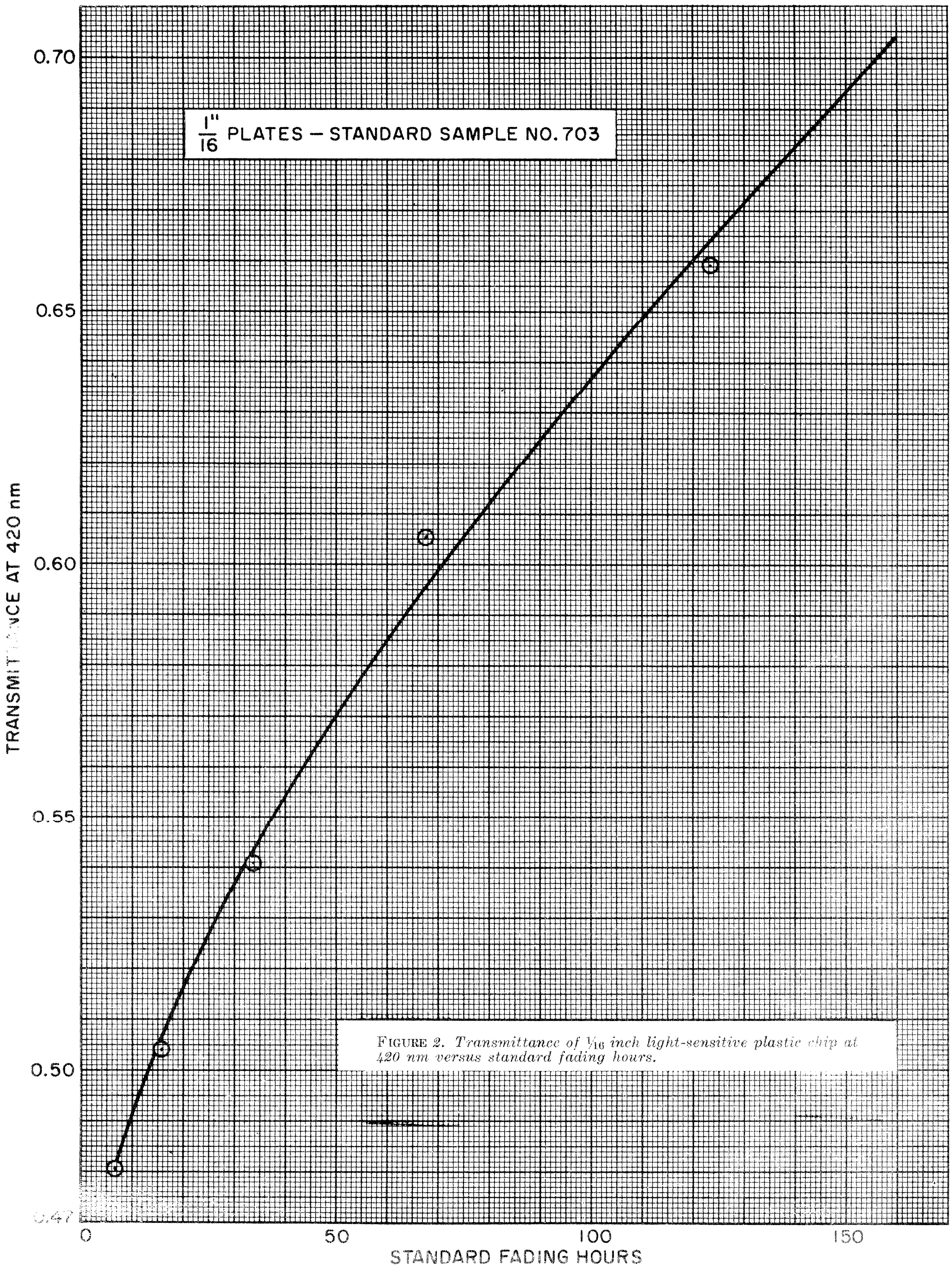

FIGURE 2. *Transmittance of 1/16 inch light-sensitive plastic chip at 420 nm versus standard fading hours.*

The data may also be represented on a plot of log T versus log SFH. However, to obtain as adequate a fit on such a plot as obtained from eq 1, a cubic equation $\log T = a + b \log \mathrm{SFH} + c (\log \mathrm{SFH})^2 + d (\log \mathrm{SFH})^3$ is required. Since equation 1 is much easier to use, it was adopted. The values of the constants for eq 1 and their standard errors are given in table 2 for calibration both by transmission measured at the minimum at 418 nm and at 420 nm. The table also gives the standard error of fit and the coefficient of variation computed from it.

Analysis was also carried out for the transmittance of each exposed plate divided by the transmittance of the unexposed half of the plate. These results showed a greater standard error of fit and it is concluded that there is no correlation between the transmittance of the exposed plate and the unexposed plate. The transmittance of the unexposed plate was measured to be 0.3859 at the 418 nm minimum and 0.3905 at 420 nm. The standard deviations were 0.0020 and 0.0021 respectively.

The results are plotted in figures 1 and 2 for transmittance at the minimum and at 420 nm against SFH respectively. The curves in these graphs are calculated from eq 1 and these are the calibration curves for this Standard Reference Material. The experimental points are also shown on these graphs.

Recommended Method of Use

It is anticipated that these plates will be used according to ASTM Method D1920–64T. However, certain factors should be borne in mind:

(a) If a spectrophotometer with different slit width from the GE Recording Spectrophotometer is used, different results from those shown in the figures will be obtained. The unexposed plate should have a measured transmittance of 0.386 at the minimum at 418 nm and 0.391 at 420 nm.

(b) This calibration was carried out at a black panel temperature of 150° ±5 °F, measured as in AATCC Test Method 16A–1964, and at a relative humidity in the lamp of 30 ±5 percent as measured by wet and dry bulb thermometers at the air exit from the test chamber of the lamp. While it is expected that relative humidity will not affect the fading rate of these plates appreciably, temperature almost certainly will and these calibration curves are therefore not certified for other temperatures.

These plates were manufactured by the Stimsonite Division, Elastic Stop Nut Corporation of America, Chicago, Illinois. The calibration was carried out at the National Bureau of Standards Institute for Materials Research by Paul J. Shouse and E. Passaglia of the Polymer Physics Section, E. Passaglia, Chief. This certificate was prepared by E. Passaglia.

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