NATIONAL BUREAU OF STANDARDS REPORT

STANDARD FILTERS FOR CALIBRATING
PHOTOGRAPHIC EXPOSURE METERS

by

Velma I. Burns

U. S. DEPARTMENT OF COMMERCE
NATIONAL BUREAU OF STANDARDS

THE NATIONAL BUREAU OF STANDARDS

Functions and Activities

The functions of the National Bureau of Standards are set forth in the Act of Congress, March 3, 1901, as amended by Congress in Public Law 619, 1950. These include the development and maintenance of the national standards of measurement and the provision of means and methods for making measurements consistent with these standards; the determination of physical constants and properties of materials; the development of methods and instruments for testing materials, devices, and structures; advisory services to government agencies on scientific and technical problems; invention and development of devices to serve special needs of the Government; and the development of standard practices, codes, and specifications. The work includes basic and applied research, development, engineering, instrumentation, testing, evaluation, calibration services, and various consultation and information services. Research projects are also performed for other government agencies when the work relates to and supplements the basic program of the Bureau or when the Bureau's unique competence is required. The scope of activities is suggested by the listing of divisions and sections on the inside of the back cover.

Publications

The results of the Bureau's research are published either in the Bureau's own series of publications or in the journals of professional and scientific societies. The Bureau itself publishes three periodicals available from the Government Printing Office: The Journal of Research, published in four separate sections, presents complete scientific and technical papers; the Technical News Bulletin presents summary and preliminary reports on work in progress; and Basic Radio Propagation Predictions provides data for determining the best frequencies to use for radio communications throughout the world. There are also five series of nonperiodical publications: Monographs, Applied Mathematics Series, Handbooks, Miscellaneous Publications, and Technical Notes.

A complete listing of the Bureau's publications can be found in National Bureau of Standards Circular 460, Publications of the National Bureau of Standards, 1901 to June 1947 ($1.25), and the Supplement to National Bureau of Standards Circular 460, July 1947 to June 1957 ($1.50), and Miscellaneous Publication 240, July 1957 to June 1960 (Includes Titles of Papers Published in Outside Journals 1950 to 1959) ($2.25); available from the Superintendent of Documents, Government Printing Office, Washington 25, D. C.

NATIONAL BUREAU OF STANDARDS REPORT

NBS PROJECT

0201-20-02625

NBS REPORT

No. 7704

Standard Filters for Calibrating Photographic Exposure Meters

by

Velma I. Burns

Prepared for

American Standards Association
ASA Subcommittee PH2-11

U. S. DEPARTMENT OF COMMERCE
NATIONAL BUREAU OF STANDARDS

Report on Standard Filters for Calibrating Photographic Exposure Meters

1. Scope.

This report describes the design and calibration of filters to be used with lamps operated at a color temperature of 2854°K for the calibration of exposure meters. The filters were designed in cooperation with ASA Subcommittee PH2-11 on Standards for Photoelectric Exposure Meters. The filters meet the requirements of American Standard PH2.12-1961 for General-Purpose Photographic Exposure Meters (Photoelectric Type).

2. Description of the Filters.

Subcommittee PH2-11 had determined that light which has a color temperature of 4700°K ± 200°K is suitable for the calibration of exposure meters. The 4700°K color temperature was chosen by PH2-11 as a compromise between the daylight color and the color of incandescent-lamp light under which the exposure meters to be calibrated are to be used. Standard lamps which operate at such a voltage that their light has a color temperature of 2854°K are commonly used and are readily available; therefore, filters which will convert the 2854°K to 4700°K were desired.

A single 6 1/2-inch square of Corning Daylite (5900) glass is used for calibrating incident-light meters; the thickness of the glass is such that it converts light of color temperature 2854°K to 4700° ± 200°K.

For calibrating reflected-light meters, a diffusing sandwich is used. The sandwich is made of a 6 1/2-inch square of special plexiglas, color W2447 White, 1/4 inch thick, manufactured by Rohm and Haas, bound to a 6 1/2-inch square of Corning Daylite (5900) glass. The glass is of such a thickness that light at 2854°K incident on one side of the sandwich is emitted at 4700 ± 200°K from the other side.

3. Tests and Calibrations.

Blue Glass Filters

The luminous transmittance of each of 70 blue glass filters, for light having a color temperature of 2854°K, was measured. The source used was a 500-watt projection lamp operating at 2854°K and measurements were made by means of a physical photometer. This is a modified form of the photometer described in NBS J. Research 27, 217 (September 1941) RP 1415. As a check on these measurements the two filters which had the highest and the lowest transmittances and one with the average transmittance of the group of filters were then measured for spectral transmittance by means of a General Electric recording spectrophotometer and their luminous transmittance computed. The results by the two methods of measurement were in accord to about 1 percent.

0201-20-02625 (Continued)

In order to determine the amount by which the filters alter the color temperature of the light they transmit, the same three filters which had been measured on the spectrophotometer were measured for color temperature of light transmitted when they were illuminated by light at 2854°K. These measurements were made by following a substitution method, with a Lummer-Brodhun photometer having a 9° x 13° double-trapezoid field. Lamp NBS1925 plus filter combination CS1-72-2 was used as a standard.

Diffusing Sandwiches

Sixty sandwiches of Corning "Daylite" (5900) glass and Rohm and Haas special plexiglas, color W2447 white, 1/4 inch thick were assembled. The diffusing characteristics of eight of these sandwiches taken at random were measured. The sandwich was illuminated along the normal from the blue glass side and measurements of relative luminance on the plexiglas side were made by means of a Photovolt photometer and again by means of a Densichron photometer. For one of the sandwiches, measurements were made on the normal to the sandwich and at 5° intervals up to 60° either side of the normal and showed that the luminance decreased monotonically with angle. The other seven specimens were measured only at 0° and at 60° each side of normal.

The color temperature of the light emitted on the plexiglas side of each sandwich for light of color temperature 2854°K incident on the blue glass side was measured. Measurements were made by visual comparison with a suitable lamp and filter which had been spectrophotometered.

The luminous directional transmittance of one sandwich, tc be used as a master standard, was determined by comparing it with a group of three laboratory standards of luminous directional transmittance, LS39, LS49, and LS51. This was done photoelectrically by first comparing the plexiglas component alone with the three standards and then determining the effect on the luminance of adding the blue glass to the plexiglas. This effect depends on the transmittance of the blue glass and the multiple reflections between the plexiglas diffuser and the glass. The value of luminous directional transmittance of the master standard thus determined was checked by determining the effect of adding a blue glass to each of the laboratory standards and then photoelectrically comparing the assembled sandwich with each of the three laboratory standards to which a blue glass of measured transmittance had been added. All of the remaining sandwiches were compared photoelectrically with the master standard that had been thus calibrated, by using a substitution method. A 3/4 inch diameter area at the center of the sandwich was used for the comparisons.

The uniformity of luminous directional transmittance of the sandwiches when viewed normal to the surface was checked by means of a photoelectric

0201-20-02625 (Continued)

cell whose sensitive surface is 1/4 inch by 1/16 inch. The sandwich was illuminated uniformly over the blue glass side. Readings were taken on the plexiglas side at the center and at 1/2 inch, 1 inch, 1 1/2 inch, 2 inches, 2 1/2 inches and 3 inches from the center along the vertical and horizontal axes perpendicular to the edges of the sandwich. Eight of the sixty sandwiches were taken at random for this measurement.

4. Results.

Blue Glass Filters

The luminous transmittance of the blue glass filters is between 0.242 and 0.248. The value for the individual filter is supplied with each standard when it is issued.

With a source at 2854°K the color temperatures of light transmitted by each of the three filters which were measured are 4750°K, 4760°K and 4830°K. These are all well within the limits of 4700 ± 200°K which is specified in Table 3 of Standard PH2.12.

Diffusing Sandwiches

The luminous directional transmittance of the sandwiches is between 0.110 and 0.115. The individual value for each sandwich is supplied with the standard when it is issued.

It was found that the color temperature of the sandwiches when illuminated by light at 2854°K ranged from 4710°K to 4810°K; this range is also well within the limits of 4700 ± 200°K which is specified in Table 3 of Standard PH2.12.

It was noted that one of the sandwiches decreased in color temperature by about 70°K after three hours use at a distance of 6 inches from a 500-watt projection lamp operating at 90 volts. The decrease in color temperature is presumably due to a rise in temperature of the sandwich. The luminance of a sandwich under the same conditions decreased by less than 1/2 percent.

When the eight sandwiches were illuminated from the blue glass side along the normal to the sandwich and viewed from the plexiglas side the luminance when viewed at 60° was found to be approximately 90% of the luminance when viewed along the normal. Accordingly, the sandwiches comply with the requirement of paragraph 3.6.3.5 of Standard PH2.12.

When the eight sandwiches were uniformly illuminated over the entire blue-glass surface, the minimum luminance of any area 1/4 inch by 1/16 inch measured at intervals of 1/2 inch up to 3 inches from the center of the sandwich on the two axes perpendicular to the sides of the sandwich was found to be no less than 90% of the maximum luminance. Accordingly, the 6-inch square area in the center of the sandwiches complies with the requirement of paragraph 3.6.3.4 of Standard PH2.12.

0201-20-02625 (Continued)

5. Summary.

A set of standards for calibrating photographic exposure meters consists of one blue glass filter and one diffusing sandwich. The blue glass filter, used for calibrating incident-light meters, converts light at 2854°K to light at 4700°K ± 200°K. The diffusing sandwich, used for calibrating reflected-light meters, converts light at 2854°K to light at 4700 ± 200°K and, when uniformly illuminated, has a 6-inch square area at the center whose luminance is uniform to within 10 percent. The luminance when viewed at 60° from the normal to the sandwich is above 90% of the luminance when viewed along the normal.

6. Precautions in Use of the Standards.

The blue-glass side of the sandwich must be illuminated uniformly-there should be no obstruction to the light incident on the entire 6 1/2-inch square area of this side.

These standards are intended to be used only for the calibrations of exposure meters that comply with the requirements of American Standard PH2.12-1961 and especially paragraph 3.7 thereof.

7. Note.

A set of standards with a report giving the luminous transmittance of the blue glass and the luminous directional transmittance of the sandwich is available at a price of $225.00 from the National Bureau of Standards, Washington 25, D.C.

U. S. DEPARTMENT OF COMMERCE
Luther H. Hodges, *Secretary*

NATIONAL BUREAU OF STANDARDS
A. V. Astin, *Director*

THE NATIONAL BUREAU OF STANDARDS

The scope of activities of the National Bureau of Standards at its major laboratories in Washington, D.C., and Boulder, Colorado, is suggested in the following listing of the divisions and sections engaged in technical work. In general, each section carries out specialized research, development, and engineering in the field indicated by its title. A brief description of the activities, and of the resultant publications, appears on the inside of the front cover.

WASHINGTON, D. C.

Electricity. Resistance and Reactance. Electrochemistry. Electrical Instruments. Magnetic Measurements. Dielectrics. High Voltage.

Metrology. Photometry and Colorimetry. Refractometry. Photographic Research. Length. Engineering Metrology. Mass and Scale. Volumetry and Densimetry.

Heat. Temperature Physics. Heat Measurements. Cryogenic Physics. Equation of State. Statistical Physics.

Radiation Physics. X-ray. Radioactivity. Radiation Theory. High Energy Radiation. Radiological Equipment. Nucleonic Instrumentation. Neutron Physics.

Analytical and Inorganic Chemistry. Pure Substances. Spectrochemistry. Solution Chemistry. Standard Reference Materials. Applied Analytical Research. Crystal Chemistry.

Mechanics. Sound. Pressure and Vacuum. Fluid Mechanics. Engineering Mechanics. Rheology. Combustion Controls.

Polymers. Macromolecules: Synthesis and Structure. Polymer Chemistry. Polymer Physics. Polymer Characterization. Polymer Evaluation and Testing. Applied Polymer Standards and Research. Dental Research.

Metallurgy. Engineering Metallurgy. Microscopy and Diffraction. Metal Reactions. Metal Physics. Electrolysis and Metal Deposition.

Inorganic Solids. Engineering Ceramics. Glass. Solid State Chemistry. Crystal Growth. Physical Properties. Crystallography.

Building Research. Structural Engineering. Fire Research. Mechanical Systems. Organic Building Materials. Codes and Safety Standards. Heat Transfer. Inorganic Building Materials. Metallic Building Materials.

Applied Mathematics. Numerical Analysis. Computation. Statistical Engineering. Mathematical Physics. Operations Research.

Data Processing Systems. Components and Techniques. Computer Technology. Measurements Automation. Engineering Applications. Systems Analysis.

Atomic Physics. Spectroscopy. Infrared Spectroscopy. Solid State Physics. Electron Physics. Atomic Physics.

Instrumentation. Engineering Electronics. Electron Devices. Electronic Instrumentation. Mechanical Instruments. Basic Instrumentation.

Physical Chemistry. Thermochemistry. Surface Chemistry. Organic Chemistry. Molecular Spectroscopy. Molecular Kinetics. Mass Spectrometry.

Office of Weights and Measures.

BOULDER, COLO.

Cryogenic Engineering Laboratory. Cryogenic Equipment. Cryogenic Processes. Properties of Materials. Cryogenic Technical Services.

CENTRAL RADIO PROPAGATION LABORATORY

Ionosphere Research and Propagation. Low Frequency and Very Low Frequency Research. Ionosphere Research. Prediction Services. Sun-Earth Relationships. Field Engineering. Radio Warning Services. Vertical Soundings Research.

Radio Propagation Engineering. Data Reduction Instrumentation. Radio Noise. Tropospheric Measurements. Tropospheric Analysis. Propagation-Terrain Effects. Radio-Meteorology. Lower Atmosphere Physics.

Radio Systems. Applied Electromagnetic Theory. High Frequency and Very High Frequency Research. Modulation Research. Antenna Research. Navigation Systems.

Upper Atmosphere and Space Physics. Upper Atmosphere and Plasma Physics. Ionosphere and Exosphere Scatter. Airglow and Aurora. Ionospheric Radio Astronomy.

RADIO STANDARDS LABORATORY

Radio Physics. Radio Broadcast Service. Radio and Microwave Materials. Atomic Frequency and Time-Interval Standards. Millimeter-Wave Research.

Circuit Standards. High Frequency Electrical Standards. Microwave Circuit Standards. Electronic Calibration Center


NBS