Color measurements have received wide development in recent decades and have found practical use in the most diverse branches of industry where color serves as an indirect indicator of the quality of articles. Colorimetric methods of monitoring production have especially important value in textile and paint-and-varnish production, in the production of building materials, etc., not even mentioning such fields as color printing, cinematography, and television, where correct color transfer is a basic problem.

The increasing interest in color measurements in the member countries of the SEV, which is reflected in the work program of the Permanent Commission on Standardization (PKS) of metrological investigations testifies to the general lifting of the people's economy, light industry, and the cultural growth of these countries. Following this program, the Permanent Commission on Standardization has started its activity with the development of recommendations for the testing and checking of color-metering instruments (the leading country is Hungary), which has substantially promoted unity of color measurements in the member countries of the SEV.

A significant part of the colorimetric work on standardization has been delegated to the Soviet Union. These works include the creation of standards and primary color measures, substantially reproducing the main elements of a checking scheme for color measurements, the working out of the techniques of making standard transparent and reflecting color specimens, and the manufacture of the specimens themselves. Special attention is being given to the standardization of the specimen of a white surface, which in the colorimetry of transparent and reflective materials has the central spot among other color specimens, since it is relative to it that evaluations are made of the coordinates of the color of all the other specimens. A big part in this plan is the work for the creation of an atlas of standard color specimens - the standard measure of the SEV, intended also for wide practical use.

Colorimetrie measurements have a characteristic feature that is not encountered in metrology, having to do with the measurement of physical quantities of the type of scalars and metrical vectors. Light, by its nature, is a three-dimensional vector in an athenium color space, and, therefore, in colorimetry we standardize not the unit of measurement, but a three-color system.

All countries have adopted the original system of color measurement physically given by the colors \( R \), \( G \), and \( B \) of three monochromatic radiations of wavelengths of 700.0, 546.1, and 435.8 nm. In this system we measure the coordinates of the spectral colors (curves of the summation of colors) of an average standard observer. In the interest of more convenient practical use and for the establishment of a simple relationship with photometric quantities there has been introduction and standardization of a system of imaginary colors \( X \), \( Y \), \( Z \) [1] linearly related to the \( R \), \( G \), and \( B \) system.

The coordinates of a color with respect to the \( X \), \( Y \), \( Z \) system are expressed by the equalities

\[
\begin{align*}
\bar{x} &= \int_{380}^{760} E(\lambda) \tau(\lambda) \bar{x}(\lambda) \, d\lambda, \\
\bar{y} &= \int_{380}^{760} E(\lambda) \tau(\lambda) \bar{y}(\lambda) \, d\lambda, \\
\bar{z} &= \int_{380}^{760} E(\lambda) \tau(\lambda) \bar{z}(\lambda) \, d\lambda,
\end{align*}
\]

where \( E(\lambda) \) is the energy distribution function in the spectrum of the source illuminating the specimen; \( \tau(\lambda) \) is the spectral component of transmission (or reflection) of the specimen; \( \bar{x}(\lambda), \bar{y}(\lambda), \bar{z}(\lambda) \) are internationally standardized
curves for the summation of colors of the average observer [curve \( y(\lambda) \) coincides with the photometric curve of visibility \( v(\lambda) \)].

In color-measuring instruments, for practical considerations, different color systems can be used. For the transfer from indications of instruments to international coordinates of a color the instruments must be calibrated with respect to color specimens illuminated by one of the light sources standardized in colorimetry. The color coordinates of these specimens (transmitting or reflecting) are determined in the international XYZ system in accordance with (1). Entirely necessary in this case is the observance of standard conditions of illumination and observation, since they in significant degree determine the measurement result. The designation of color specimens in addition is the effecting of regular and periodic monitoring of the indications of color-measuring instruments for revealing and eliminating possible systematic errors. Therefore, color specimens should be stable and unchanging with time, i.e., manufactured of reliable materials.

From representations of color as a three-dimensional vector it follows that for the assignment of a colorimetric system, equally for the calibration and checking of color-measuring instruments, it is sufficient to have three standard specimens the colors of which are linearly independent of each other. The practice of color measurement has shown, however, that existing variations in the curves of summation of colors by observers having normal color perception, as well as the errors in reproduction of curves of summation of colors in photoelectric colorimeters, introduce systematic errors into the measurement of the coordinates of a color, and which substantially increase the random errors in measurements of separate observers or separate photoelectric instruments. Especially sharp are the systematic errors with large differences of the spectral compositions of the comparison fields in colorimeters. This so-called phenomenon of metamerism substantially complicates the implementation of accurate color measurements and is eliminated by expanding the set of standard color specimens and the use of a measurement method in which the color of the tested specimen is compared with the color of a standard specimen of close spectral composition with the aid of a comparator. In this connection there arises the question of the required and sufficient number of standard specimens depending on the requirements for accuracy of the color measurements and the latitude of the scales of the comparators.

The choice of the number of specimens and the determination of their positions in the colored body was the subject of a special investigation of the All-Union Scientific-Research Institute of Metrology (VNIIM) [2]. The results of this investigation have permitted, in the establishment of the technical conditions for the manufacture of specimens, the formulation of requirements for the color coordinates of specimens.

The material that is most reliable and stable with time for the manufacture of color specimens is optically transparent and nontransparent (deadened during boiling) colored glass, and also colored enamels. Therefore the sets of color specimens were made in the VNIIM from transparent colored glasses of different sorts of domestic production by varying their thicknesses. The sets consist of 34 plane-parallel polished plates measuring 40 x 40 mm and include the following groups of specimens:

1) three neutral glasses NS-8 of different thickness and one neodymium glass PS-7;
2) six glasses of weakly saturated colors PS-5, OS-6, Zhs-11, SZS-24, SS-13, and PS-14;
3) eight glasses of colors of medium saturation PS-8, OS-5, ZhZS-4, ZhZS-9, SZS-6, SS-6, and PS-15;
4) seven glasses of saturated colors KS-13, OS-12, Zhs-18, ZS-2, SZS-3, SS-8, and PS-15;
5) nine glasses (three subgroups of marks PS-5, SS-6, NS-1) having small color differences in each subgroup.

Specimens of the 1st group are intended for the checking of photometric scales and wavelength scales of spectrophotometers in the range of wavelengths of the visible spectrum. Glasses of the 2nd, 3rd, and 4th groups are intended for checking the scales of colorimeters; glasses of the 5th group are for checking the scales of comparators.

Spectral coefficients of transmission are measured on the standard spectrophotometer of the VNIIM. Color coordinates are computed for source A on the basis of spectrophotometric values and data about the curves of summation of colors of the average standard observer of the International Commission on Illumination of 1931.

Sets of reflecting color specimens have been developed by the Hungarian People's Republic. The sets contain 16 specimens each in the form of flat disks 75 mm in diameter and manufactured from low-carbon glass having bright different-colored enamel coatings. Fourteen disks reproduce red, yellow, green, and blue colors of different saturation, and the remaining two disks reproduce white and grey.