NATIONAL BUREAU OF STANDARDS REPORT

4456

COMPARATIVE TABLE

CHROMATICITY REQUIREMENTS OF U.S. AND INTERNATIONAL SPECIFICATIONS AND STANDARDS

FOR

AVIATION SIGNAL LIGHT COLORS

Prepared for

Airport Lighting and Marking Panel

U. S. DEPARTMENT OF COMMERCE
NATIONAL BUREAU OF STANDARDS

U. S. DEPARTMENT OF COMMERCE
Sinclair Weeks, *Secretary*

NATIONAL BUREAU OF STANDARDS
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- Office of Basic Instrumentation
- Office of Weights and Measures

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by

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U. S. DEPARTMENT OF COMMERCE
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Symbol	Specifications Included in Tables	Date
	U. S. Specifications and Standards	
AN-C-56	Army-Navy Aeronautical Specification, Colors; Aeronautical Lights and Lighting Equipment.	25-VI-42
AN-C-56 Amend-3	Ditto	6-VI-45
Fed. Std. No.3 Amend-1	Federal Standard, Colors, Aeronautical Lighting	27-VIII-51
MIL-C-25050 (ASG)	Military Specification, Colors, Aeronautical Lights and Lighting Equipment, General Requirements for	29-X-54
-------	Proposed U.S. Standard for the Colors of Signal Lights; Part I, Definitions Underlying the Specification of Colors for Signal Lights	1955
	International Standards and Recommendations	
I.C.A.O.	International Standards and Recommended Practices, Aerodromes, Annex 14 to the Convention on Civil Aviation.	1-IX-53
C.I.E.	International Commission on Illumination, Recommendations of the 13th Session, 1.3.3 Colors of Signal Lights	1955

Explanatory Statement

The accompanying tables show the equations used as boundaries for the aviation signal-light colors in the United States together with the corresponding equations used in the standards of the International Civil Aviation Organization and the 1955 Recommendations of the International Commission on Illumination. All the equations are expressed in the coordinates of the C.I.E. system, which is the system used in all the specifications, but since the R-U-C-S equivalents of the C.I.E. recommendations are not available elsewhere, a column has been added to give these also.

The purpose of these tables is to bring out similarities and differences between the several specifications; hence, instead of repeating an equation for each specification in which it occurs, repetitions are emphasized by references to the appropriate columns. To further facilitate comparisons, certain conventions which had already been followed in the form of all of the international specifications have been applied to the U. S. specifications also. These include the elimination of z, the selection of the independent variable to keep the coefficient less than 1.000, and the placing of the constant ahead of the variable on the righthand side of the equation. When necessary, the original equations in the U. S. specifications have been transformed to conform with these conventions but such transformations do not change the mathematical significance of the equations.

Even when the specifications are in the same form, it is still difficult to appraise the difference between two chromaticity boundaries from their equations. The tables are, therefore, accompanied with a set of 4 diagrams showing the boundaries of the several colors in the different specifications. Three of these diagrams were originally prepared to show how the Proposed U. S. Standard is related to existing specifications and for that reason these diagrams include the boundaries of several specifications that are not used for aviation purposes and are not included in the tables. Figure 1 shows the entire mixture diagram and gives a general view of the relationship of the reds at the bottom, the greens at the top, and the blues on the left to the white/yellow region in the center. Figure 2 presents the new C.I.E. treatment of the central yellow/white region. Figure 3 shows the boundaries for white in different specifications. Figure 4 compares the hue requirements for red and yellow in the U. S. and international specifications.

The C.I.E. yellow/white recommendations, Figure 2, require some explanation. The entire area within the outer boundaries, including the cross-hatched portions, is regarded as essentially one color and any part of this area is recognizable, under usual conditions of

observation, as being neither red nor green. To this entire range of chromaticities the term "yellow/white" has been applied. Under favorable conditions, it is practicable to divide this region into two regions, that is a yellow and a white, the boundaries depending upon the conditions of use. These restricting boundaries are shown in Figure 2. In the case of the distinguishable white, it is also necessary to insure a reasonable separation of signal chromaticities by a suitable selection of limit filters so that only the redder yellows will be seen when the white signals are in the yellower part of the allowed white region. This arrangement is necessary to provide for yellowing of the white signals as their intensity is lowered.

Comparative Table of Identification-

Light Color Specifications

Color	Boundary	AN-C-56 Original 1942	AN-C-56 Amended 1943	Federal Standard No. 3 1951	U. S. Standard Proposed
Red	Purple	$x + y = 0.999$	do	AN-C-56	$x + y = 0.998$
	Yellow	$y = 0.287$	do	AN-C-56	$x - y = 0.410$
Yellow	Red	$y = 0.370$	do	AN-C-56	$y = 0.382$
	White	$x + y = 0.995$	do	AN-C-56	$x+y=0.872+0.200x$
	Green	$y = 0.423$	do	$x = 0.570$	$x = 0.555$
Green	Yellow	$x = 0.312$	do	AN-C-56	$y = 0.730(1-x)$
	White	$x=-0.214+0.833y$	do	AN-C-56	$x = 0.425y$
	Blue	$y=+0.663-0.833x$	do	AN-C-56	$y=0.500-0.500x$
White (lunar)	Yellow	$x = 0.440$	do	AN-C-56	$x=0.250+0.500y$
	Blue	$x = 0.240$	do	AN-C-56	$x=0.350-0.300y$
	Green	$y - y_o = 0.015$	do	AN-C-56	$\lvert x - x_o \rvert = 0.008$ $y - y_o = 0.008$
	Purple	$y_o - y = 0.015$	$y_o - y = 0.045$	do	$\lvert x - x_o \rvert = 0.008$ $y_o - y = 0.008$
Signal Red	Purple			$x + y = 0.999$	
	White			$y = 0.304$	
Signal Green	Yellow			$x = 0.312$ *	
	White			$x=-0.214+0.833y$ *	
	Blue			$y=+0.663-0.833x$ *	

do, same as previous column.

*, same as identification green.

Requirements of MIL-C-25050 are identical with those of AN-C-56 Amended.

Comparative Table of Aviation Signal-Light Color Specifications

Specification		I.C.A.O. Standard	AN-C-56 Original	AN-C-56 Amended	Federal Standard No. 3	Mil-C-25050	C.I.E. Recommendations	U.S.Standard (Proposed)	C.I.E. of 1955 R-U-C-S Coordinates
Color	Boundary	1952	1942	1945	1951	1954	1955	1955	
Red	Purple	$x + y = 0.980$	$x + y = 0.998$	do	$x + y = 0.997$	AN-C-56	I.C.A.O.	Fed. Std. No. 3*	$x'' = 0.070$
	Yellow	$y = 0.335$	I.C.A.O.	do	I.C.A.O.	I.C.A.O.	I.C.A.O.	$x - y = 0.330$	$y''=-0.317-4\Delta x''$#
Yellow (Variable)	Red	$y = 0.382$	---	$y = 0.370$	$y = 0.385$	AN-C-56 Amended	I.C.A.O.	I.C.A.O	$y''=-0.225-4\Delta x''$#
	White	$y=0.790-0.667x$	---	$x + y = 0.995$	$x + y = 0.990$	AN-C-56 Amended	I.C.A.O.	$x+y=0.928+0.100x$ ***	$x''=+0.063-0.050y''$
	Green	$x = 0.550$	---	$y = 0.425$	I.C.A.O.	AN-C-56 Amended	$x - y = 0.120$	I.C.A.O.	$y''=-0.134-0.5\Delta x''$
Yellow	Red	$y = 0.400$	$y = 0.402$	---	I.C.A.O.	---	---	I.C.A.O.	---
	White	$y=0.790-0.667x$	$x + y = 0.993$	---	$x + y = 0.990$	---	---	$x+y=0.928+0.100x$ ***	---
	Green	$x = 0.560$	$y = 0.460$	---	I.C.A.O.	---	---	I.C.A.O.	---
Green	Yellow	$x = 0.333$	$x=0.440-0.320y$	do	$x=0.390-0.171y$	AN-C-56	$x=0.360-0.080y$	C.I.E.	$x'' = +0.715y''$
	White	$x = 0.650y$	$x = -0.170 + y$	do	$x=0.100+0.410y$	AN-C-56	I.C.A.O.	I.C.A.O.	$y''=+0.085-0.600x''$
	Blue	$y=0.390-0.171x$	I.C.A.O.	do	I.C.A.O.	I.C.A.O.	I.C.A.O.	I.C.A.O.	$x'' = -0.150y''$
Blue	Green	$y=0.065+0.805x$	$x = y$	do	$y=0.060+0.820x$	AN-C-56	I.C.A.O.	I.C.A.O.	$x'' = -0.950y''$
	White	$x = 0.400 - y$ ##	$x = 0.175$	do	I.C.A.O.	AN-C-56	I.C.A.O.	I.C.A.O.	$x''=-0.125+0.350y''$
	Violet	$x=0.133+0.600y$	$x = 0.175$	do	I.C.A.O.	AN-C-56	I.C.A.O.	$x=0.100+0.700y$	$y'' = -0.205x''$
White (Variable)	Yellow	$x = 0.560$	$x = 0.540$	do	I.C.A.O.	AN-C-56	$x=0.255+0.750y$ $y=0.790-0.667x$	$x=0.250+0.750y$	$y''=-0.161+0.086x''$ $x''=+0.063-0.050y''$
	Blue	$x = 0.310$	$x = 0.350$	do	$x = 0.350$	AN-C-56	I.C.A.O.	$x = 0.325$	$x''=-0.025+0.984y''$
White	Yellow	$x = 0.500$	---	---	$x = 0.470$	---	I.C.A.O.	$x=0.250+0.585y$	$x''=+0.100+0.420y''$
	Blue	$x = 0.310$	---	---	$x = 0.350$	---	I.C.A.O.	$x = 0.325$	$x''=-0.025+0.984y''$
White (both)	Green	$y=0.640-0.400x$	$y - y_o = 0.01$	do	$y - y_o = 0.030x$	AN-C-56	$y = 0.440$	$\lvert x - x_o\rvert = 0.009$** $y - y_o = 0.009$**	$x''=+0.042-0.247y''$
	"	$y=0.150+0.640x$	---	---	---	---	I.C.A.O.	---	$x''=+0.020-0.700y''$
	Purple	$y=0.050+0.750x$	$y_o - y = 0.01$	do	$y_o - y = 0.030x$	AN-C-56	I.C.A.O.	$\lvert x - x_o\rvert = 0.009$** $y_o - y = 0.009$**	$x''=-0.026-0.900y''$
	"	$y = 0.390$	---	---	---	---	$y = 0.382$	---	$x''=+0.021-0.240y''$

*Proposed revision $x + y = 0.992$ **Proposed revision $\lvert x - x_o\rvert = 0.008$, $y - y_o = 0.008$, $y_o - y = 0.008$ #$\Delta x'' = x'' - 0.075$

***Proposed revision $x + y = 0.872 + 0.200x$, ##Recommended Practice

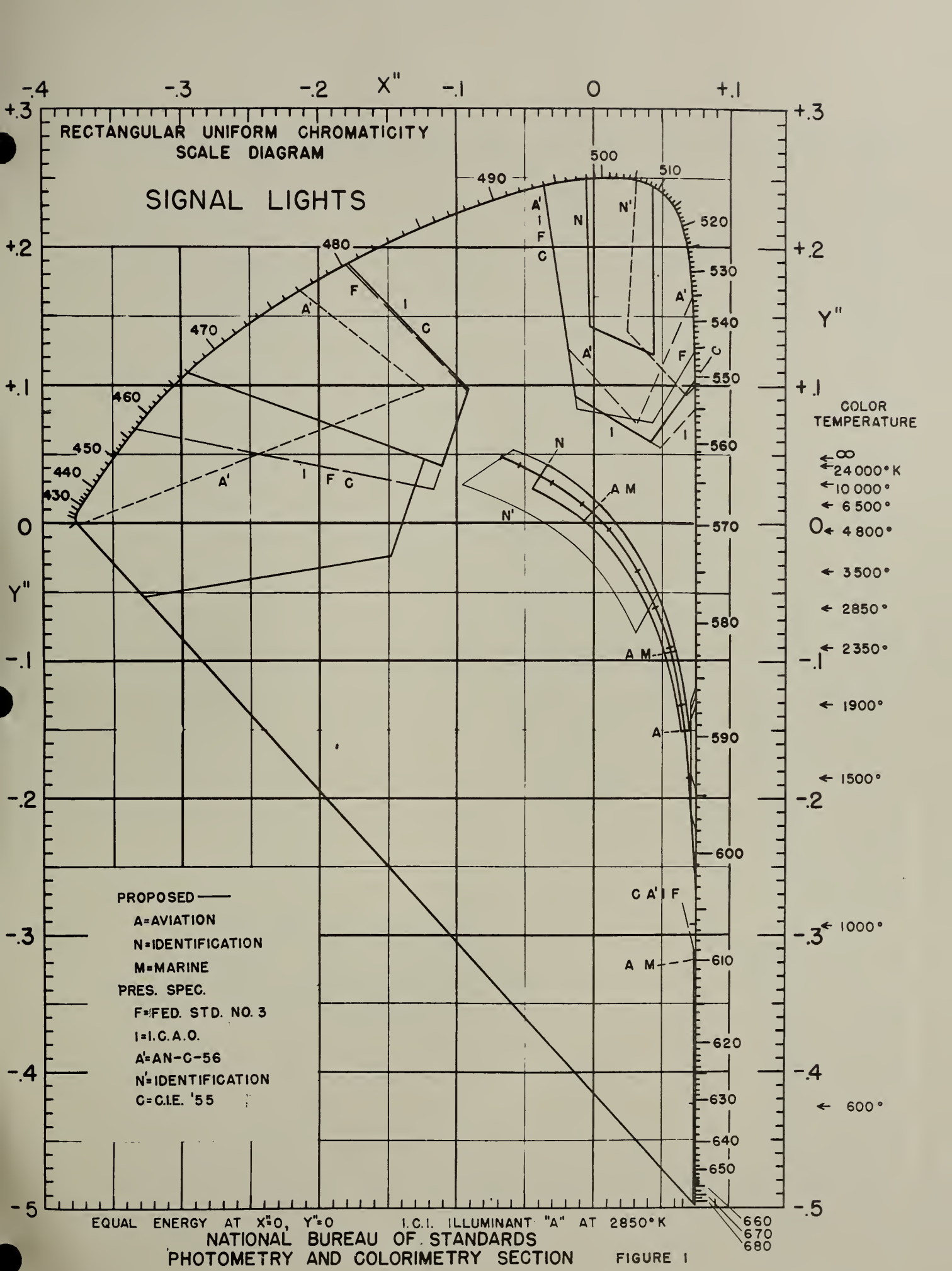
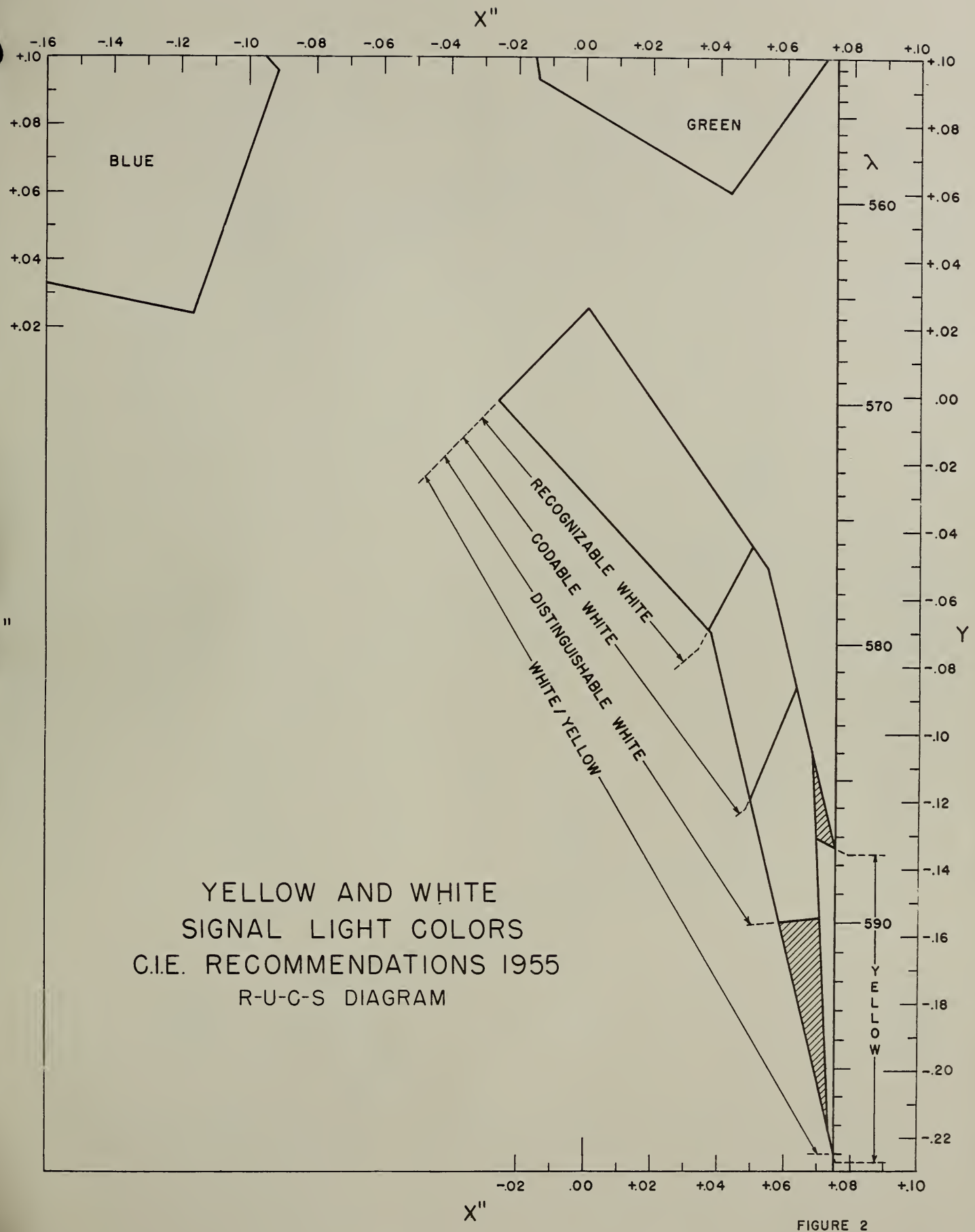

RECTANGULAR UNIFORM CHROMATICITY SCALE DIAGRAM
SIGNAL LIGHTS
X"
Y"
-.4
-.3
-.2
-.1
0
+.1
+.2
+.3
-.5
490
500
510
520
530
540
550
560
570
580
590
600
610
620
630
640
650
660
670
680
480
470
460
450
440
430
A'
I
F
C
N
N'
A M
A
C A' I F
COLOR TEMPERATURE
∞
24 000° K
10 000°
6 500°
4 800°
3500°
2850°
2350°
1900°
1500°
1000°
600°
PROPOSED
A=AVIATION
N=IDENTIFICATION
M=MARINE
PRES. SPEC.
F=FED. STD. NO. 3
I=I.C.A.O.
A'=AN-C-56
N'=IDENTIFICATION
C=C.I.E. '55
EQUAL ENERGY AT X"=0, Y"=0
I.C.I. ILLUMINANT "A" AT 2850° K
NATIONAL BUREAU OF STANDARDS
PHOTOMETRY AND COLORIMETRY SECTION

FIGURE 1



YELLOW AND WHITE
SIGNAL LIGHT COLORS
C.I.E. RECOMMENDATIONS 1955
R-U-C-S DIAGRAM

FIGURE 2

WHITE SIGNAL LIGHT COLORS

R-U-C-S DIAGRAM

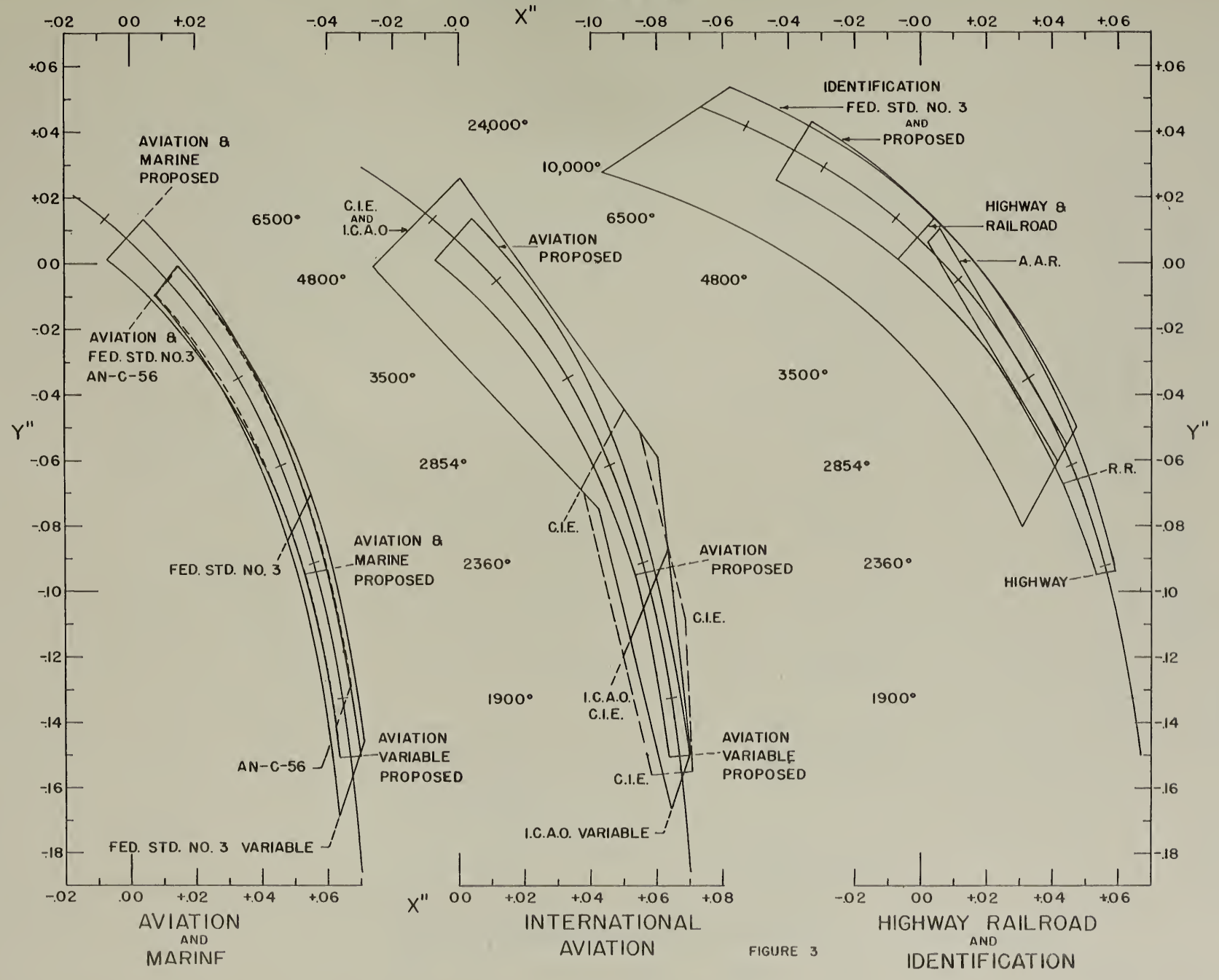
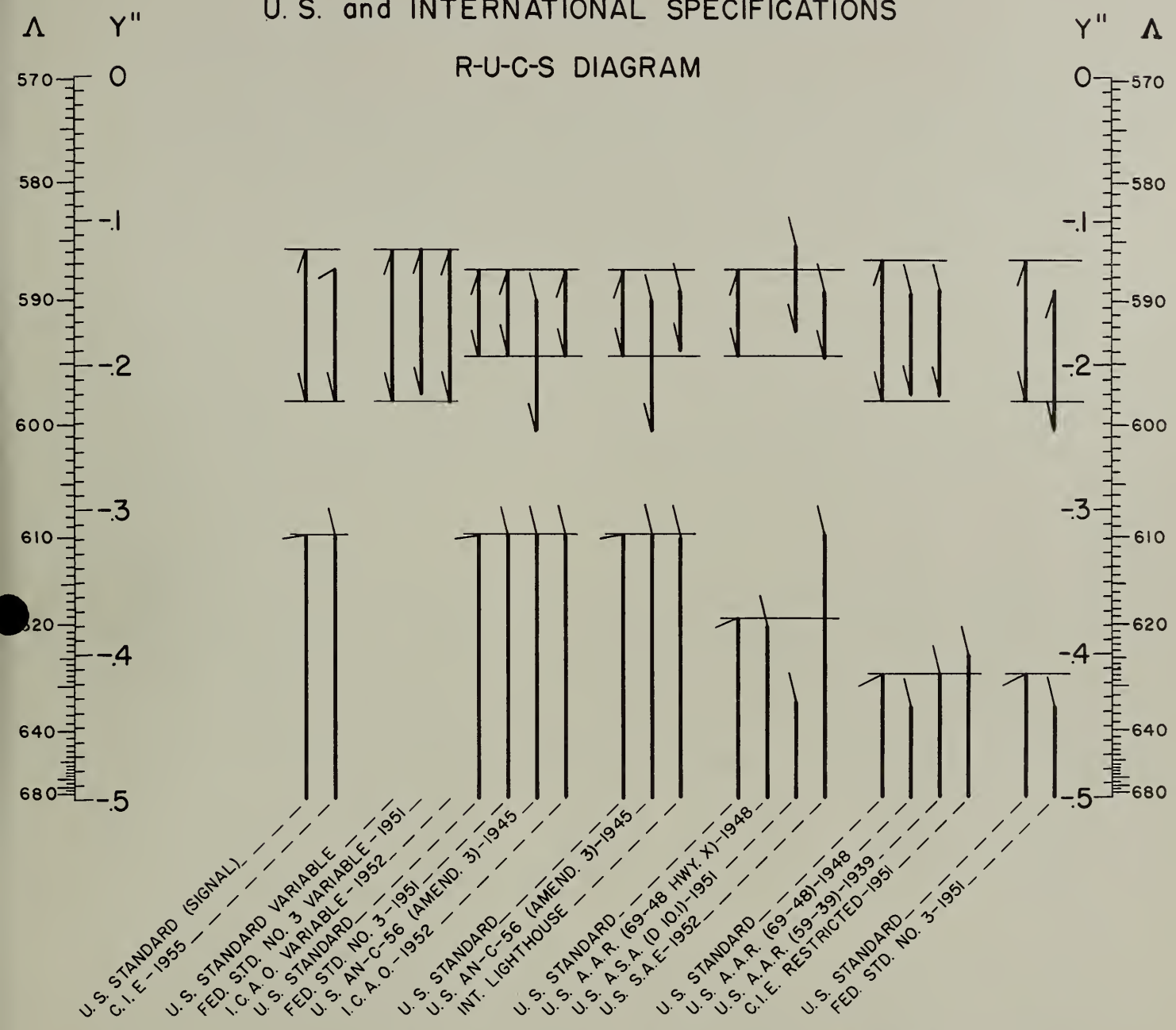


FIGURE 3

COMPARISON OF LIMITS FOR RED AND YELLOW SIGNAL LIGHT COLORS

U. S. and INTERNATIONAL SPECIFICATIONS

R-U-C-S DIAGRAM



GENERAL AVIATION MARINE HIGHWAY RAILROAD IDENTIFICATION

FIGURE 4

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. A major portion of the Bureau's work is performed for other Government Agencies, particularly the Department of Defense and the Atomic Energy Commission. The scope of activities is suggested by the listing of divisions and sections on the inside of the front cover.

Reports and Publications

The results of the Bureau's work take the form of either actual equipment and devices or published papers and reports. Reports are issued to the sponsoring agency of a particular project or program. Published papers appear either in the Bureau's own series of publications or in the journals of professional and scientific societies. The Bureau itself publishes three monthly periodicals, available from the Government Printing Office: The Journal of Research, which presents complete papers reporting technical investigations; the Technical News Bulletin, which presents summary and preliminary reports on work in progress; and Basic Radio Propagation Predictions, which provides data for determining the best frequencies to use for radio communications throughout the world. There are also five series of nonperiodical publications: The Applied Mathematics Series, Circulars, Handbooks, Building Materials and Structures Reports, and Miscellaneous Publications.

Information on the Bureau's publications can be found in NBS Circular 460, Publications of the National Bureau of Standards ($1.25) and its Supplement ($0.75), available from the Superintendent of Documents, Government Printing Office. Inquiries regarding the Bureau's reports and publications should be addressed to the Office of Scientific Publications, National Bureau of Standards, Washington 25, D. C.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