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AMERICAN NATIONAL STANDARD

American National Standard

ANSI Z535.1-1998

AMERICAN NATIONAL STANDARD

SAFETY
COLOR
CODE

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION
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AMERICAN NATIONAL STANDARD

SAFETY COLOR CODE

Secretariat

National Electrical Manufacturers Association

Approved February 23, 1998

American National Standards Institute

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Forward (This foreword is not part of American National Standard for Safety Color Code, Z535.1-1998)

This standard, approved by ANSI on March 2, 1998, is a revision of the ANSI Z535.1-1991 *Safety Color Code* which, in turn, was a revision of the American National Standard, *Safety Color Code for Marking Physical Hazards,* Z53.1-1979.

In 1979, the Z53 Committee on Safety Colors was combined with the Z35 Committee on Safety Signs to form the Z535 committee on Safety Signs and Colors. This committee has the following scope:

> "To develop standards for the design, application, and use of signs, colors, and symbols intended to identify and warn against specific hazards and for other accident prevention purposes."

Five subcommittees were created and assigned the tasks of updating the Z53 and Z35 standards, and writing two new standards. The five standards included:

Z535.1 - Safety Color Code, which updates Z53.1 (1979)

Z535.2 - Environmental and Facility Safety Signs, which updates Z35.1 (1972).

Z535.3 - Criteria for Safety Symbols and Labels, a new standard.

Z535.4 - Product Safety Signs and Labels, a new standard.

Z535.5 - Accident Prevention Tags (for Temporary Hazards), which updates Z35.2 (1974).

Together, these five standards contain the information needed to specify formats, colors, and symbols for safety signs used in environmental and facility applications (Z535.2), product applications (Z535.4), and temporary accident prevention tags (Z535.5).

It is desirable that new safety signs, labels, symbols and colors comply with these standards.

This Safety Color Code Standard is the sixth revision of the American War Standard, developed at the request of the War Department and approved by the American Standards Association (ASA) on July 16, 1945. The ASA was reconstituted as the USA Standards institute (USASI) in August 1966, and as the American National Standards Institute (ANSI) in October 1969. Peacetime work on revising the American War Standard containing the Safety Color Code began in 1946 under committee procedures of the ASA, with the National Safety Council serving as sponsor of the project. The Sectional Committee on the Safety Color Code, Z53, reviewed the War Standard and enlarged its application to include the colors orange, blue, and purple. The committee also approved standard definitions and limits for the colors. The revised standard was approved by the ASA on September 11, 1953. In the 1971 revision, the Z53 committee deleted the color blue and modified the application of the color yellow, due to conflicts with other American National Standards.

In the fourth revision, a significant step forward was made toward increased safety through uniformity in safety color coding. The safety color codes formerly used in this standard were combined and adjusted to give the best feasible discrimination for observers with either normal or color-deficient (colorblind) vision. For the first time, safety color tolerance charts were available for use with this standard (see reference 17). Each color tolerance chart shows the standard color and six color tolerances illustrating acceptable ranges in hue, value (lightness) and chroma (saturation). Each color tolerance chart also lists the Munsell notation and equivalent CIE specifications (x,y,Y) for each standard color and tolerance sample. The colors brown, blue, and gray were added, and Table 1 was expanded to include the same information on most of the levels of the Universal Color Language (UCL) for the tolerance samples as for the standard or central sample of each Safety Color. Sections 1-6 of the present standard contain material similar to the fourth revision (Z53.1, 1979).

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The intent of the fifth revision (1991) of the safety color standard was to provide a series of visually distinguishable safety colors, each with specific uses. This 1998 version, the sixth revision, incorporates corrections and additions that help to clarify the use of this standard in conjunction with the other Z535 standards. This revision also adds an annex that explains how to relate the CIE safety color specifications contained in Table 1 with the CIE chromaticity diagrams illustrated in Figures 1, 2 and 3.

It is important to note that the color-rendering characteristics of several types of modern, high-efficiency light sources differ markedly from those of the average daylight source (CIE Source C) specified in Table 1. It is therefore essential that candidate safety colors be examined under the actual light sources to be used in order to ensure that they can be suitably differentiated and individually identified with their assigned color names.

The limited color gamut and aging characteristics of fluorescent colorants combine to restrict the number and chromaticities of fluorescent safety colors. For this reason, categories of unrestricted red-orange and unrestricted yellow fluorescent colors have been added to supplement the restricted specifications that are equivalent to CIE international standards. The unrestricted specifications may be used when no more than three distinguishable fluorescent safety colors are required for outdoor use for up to two years.

Recent research is providing conclusive evidence that highly chromatic colors, in some chromaticities, serve to increase or decrease the perception of lightness (for reflective materials) and brightness (for self-luminous objects). The effect is more dramatic in the case of colored lights and colored retroreflective materials. Future revisions of this standard might consider opportunities for improving the visibility of safety signs, colors and symbols through the selective use of vividly colored retroreflectors as well as include test methods and color specifications for retroreflective and self-luminous materials.

For this revision of the ANSI Z535.1 standard, special appreciation and thanks are extended to Nick Hale for his expert guidance.

Suggestions for improvement of this standard are welcome. They should be sent to the American National Standards Institute, 11 W. 42nd Street, New York, New York 10036.

This standard was processed and approved for submittal to ANSI by the American National Standards Committee on Safety Signs and Colors, Z535. Committee approval of this standard does not necessarily imply that all committee members voted for its approval, but that a consensus of all members was obtained.

At the time this standard was approved, the Z535 Committee had the following members:

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Anthony L. Martino, Vice Chairman
Ronald R. Runkles, Secretary

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At the time of approval, the Z535.1 Subcommittee had the following members:

Geoffrey Peckham, Chair	**Nick Hale**
	Norbert Johnson

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American National Standard

for Safety Color Code

1 Introduction

Color schemes for the identification and location of fire extinguishers, first aid kits, traffic aisleways, stumbling and tripping hazards, radiation, etc., have been developed in the past by a large number of industrial firms and other organizations.

Generally speaking, these color schemes have given satisfaction to those using them in individual plants. They suffer, however, from lack of uniformity among plants or organizations. As a result, spontaneity of action in times of emergency is lost, particularly by employees who have moved from one plant to another, when each has a different system.

In order to increase uniformity of safety color coding within and between plants and organizations, and to increase spontaneity of action in times of emergency, the safety color code has been adjusted to give the best feasible color discrimination for observers of both normal and color-deficient vision (colorblind). As a result, the safety colors are the same as those used with: American National Standard for Environmental and Facility Safety Signs, ANSI Z535.2-1998; American National Standard for Criteria for Safety Symbols, ANSI Z535.3-1998; American National Standard for Product Safety Signs and Labels, ANSI Z535.4-1998; American National Standard Scheme for the identification of Piping Systems, ANSI A13.1 (1985); American National Standard Radio Frequency Radiation Hazard Warning Symbol, ANSI C95.2 (1982) (R 1988); The Department of Transportation (DOT) Hazardous Materials Warning Labels and Placards; and the National Highway Traffic Safety Administration (NHTSA, DOT) Ambulance Orange and Ambulance Blue (see References 10 and 11).

It is intended that use of this Safety Color Code will supplement the proper guarding or warning of hazardous conditions. The marking of a physical hazard by a standard color warning should never be accepted as a substitute for the reduction or elimination of the hazard whereever possible.

It is recognized also that too many color identifications constantly in the field of vision of the employees are both confusing and fatiguing. Each location should, therefore, be carefully studied in order to keep the number of markings at a minimum, thereby providing even greater emphasis for the markings that are finally adopted and used.

2 Scope

This standard sets forth the technical definitions, color standards and color tolerances for safety colors, and the applications of these safety colors to specific purposes in connection with accident prevention.

3 Purpose

3.1 The intent of this standard is to establish a safety color code that will alert and inform persons to take precautionary action or other appropriate action in the presence of hazards.

3.2 This standard is not a substitute for engineering or administrative controls, including training, to eliminate identifiable hazards.

3.3 There are a number of existing American national standards which are recognized for particular industries or specific uses. Compliance with these standards may be considered for such particular industries or uses. It is not the intent of this ANSI Z535.1 standard to replace existing standards or regulations which are uniquely applicable to a specific industry or use. It is the intent to encourage adoption of this standard in subsequent revisions of other standards and regulations.

4 Application

4.1 The criteria of this standard shall apply to the use of safety color coding for the identification of physical hazards, the location of safety equipment,

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protective equipment, stationary machinery, portable powered hand tools, structures and facilities. For chemical products and chemical mixtures follow ANSI Z129.1-1994.

4.2 The colors specified in this standard are intended for use on safety signs and symbols as set forth by other Z535 standards. See Z535.2, Z535.3, Z535.4, and Z535.5.

4.3 This standard shall apply to the use of the safety colors to minimize the possibility of accident or injury.

4.4 This standard sets forth the specifications of the safety colors for as wide a range of materials as possible to satisfy the many applications for these colors.

4.5 Locations, objects, or safety signs that are color coded and for which illumination must be provided shall be illuminated to levels which will permit positive identification of the color and the hazard or situation which the color identifies. These locations, objects, or safety signs shall be illuminated with a light source which will not overly distort the color and, therefore, the message the color identification conveys.

4.6 To ensure optimum visibility, colors selected for safety signs should have maximum color contrast, especially lightness contrast. Likewise, contrast must be achieved between the sign and its visual environment. Thus, dark colors (red, brown, green, blue, and purple) should be used with white letters, while light colors (orange and yellow) are better seen contrasted with black.

5 Exceptions

The authority having jurisdiction may permit variations from this standard only when equal or greater safety is provided.

6 Color meaning

This section provides meanings for the safety colors which are specified in this standard. Table 1 provides fundamental colorimetric specifications for each color.

6.1 Safety red

Safety Red shall be the color for the identification of DANGER and STOP.

6.1.1 Commonly used examples. The following are some common examples of applications where the color Safety Red may be used:

1) The background color of the signal word panel for DANGER safety signs, labels and tags (see ANSI Z535.2, ANSI Z535.4 and ANSI Z535.5).

2) Flammable liquid containers such as safety cans.

3) Emergency stop bars on machines.

4) Stop buttons or electrical switches used for emergency stopping of machinery.

5) Fire protection equipment and apparatus.

6) References 1, 8, 9, 10, 11, 12, 13, and 14.

6.2 Safety orange

Where an intermediate level of hazard (i.e. WARNING) is used, the color shall be Safety Orange. If a color is to be used to identify the hazardous parts of machines, Safety Orange shall be used.

6.2.1 Commonly used examples. The following are some common examples of applications where the color Safety Orange may be used:

1) The background color of the signal word panel for WARNING safety signs, labels and tags (see ANSI Z535.2, ANSI Z535.4 and ANSI Z535.5).

2) Marking hazardous parts of machines which may cut, crush, or otherwise injure; and emphasizing such hazards when enclosure doors are open or when gear, belt, or other guards around moving equipment are open or removed, exposing unguarded hazards.

3) Marking the inside of movable guards or the inside of transmission guards for gears, pulleys, chains, etc. Marking exposed parts (edges only) of pulley, gears, rollers, cutting devices, power jaws, etc.

4) References 1, 8, 9, 10, 11, and 13.

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6.3 Safety yellow

Safety Yellow shall be the color for the identification of CAUTION. Solid yellow, yellow and black stripes, or yellow and black checkers shall be used for maximum contrast with the particular background.

6.3.1 Commonly used examples. The following are some common examples of applications where the color Safety Yellow may be used:

1) The background color of the signal word panel (for CAUTION safety signs, labels and tags, see ANSI Z535.2, ANSI Z535.4 and ANSI Z535.5).

2) Marking physical hazards which might result in: striking against, stumbling, falling, tripping, or being caught in-between.

3) Storage cabinets for flammable materials. For containers of flammable or combustible materials (see Section 6.1.1).

4) Containers for corrosives, or unstable materials. Such containers shall be yellow or identified by a yellow band around their middle at least 1/4 their height. The contents of the container shall be identified thereon.

5) References 1, 8, 9, 10, and 13.

6.4 Safety green

Safety Green shall be the color for emergency egress, and the location of first aid and safety equipment.

6.4.1 Commonly used examples. The following are some common examples of applications where the color Safety Green may be used:

1) The background color of the signal word panel for general safety signs (see ANSI Z535.2).

2) Gas masks.

3) First aid kits.

4) First aid dispensary.

5) Stretchers.

6) Safety deluge showers.

7) Safety bulletin boards.

8) Emergency egress routes.

9) References 1, 8, 9, 10, 13.

6.5 Safety blue

Safety Blue shall be the color for the identification of safety information used on informational signs and bulletin boards. Safety Blue also has specific applications in the railroad area to designate warnings against the starting, use of, or movement of equipment that is under repair or being worked upon.

6.5.1 Commonly used examples. The following are some common examples of applications where the color Safety Blue may be used:

1) The background color for the signal word panel for NOTICE and informational safety signs (see ANSI Z535.2).

2) Mandatory action signs for wearing of personal protective gear such as hard hats.

3) References 1, 8, 9, 10, and 11.

6.6 Safety purple. Color meanings have not been assigned for Safety Purple. References 8, 9, 10, and 15.

6.7 Safety white, gray, black, and brown. Individual color meanings and applications have not been assigned for Safety White, Safety Gray, Safety Black, and Safety Brown.

6.8 Traffic and housekeeping colors. Safety Black, Safety White, Safety Yellow, or combinations of Safety Black with Safety White or Safety Yellow shall be the colors for the designation of traffic or housekeeping markings.

Examples of applications of the color Safety White and Safety Black are given in footnote references 1, 8, 9, 10, and 12.

7 Color specifications and test methods for ordinary surface colors

7.1 Color specifications

7.1.1 The primary color specifications are in terms of the Munsell Notation System, a color identification

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and specification system based on uniform visual spacing as described in Standard Practice for Specifying Color by the Munsell System, ASTM D1535 (reference 16). Table 1 lists the Munsell notations for each standard and its surrounding tolerance limits, and provides equivalent data in the CIE 1931 system for use in section 7.3.

7.1.2 The Color Tolerance Charts designed for use with this standard (see section 7.2.1 and reference 17) display the standard color and three pairs of tolerance colors, representing the upper (+) and lower (-) limits for the visual attributes of hue, value and chroma. Table 1 shows the Munsell notations for each of these seven colors and the equivalent CIE x,y,Y data, for CIE Standard Illuminant C and the 2° CIE 1931 Standard Observer. Table 1 also gives the boundary equations of permissible areas on the CIE 1931 Chromaticity Diagram and the luminous reflectance of the standard (Y) . Figure 1 shows the CIE 1931 Chromaticity Diagram on which the permissible areas are defined by the boundary equations and the color names and Munsell Notations for each Safety Color.

7.1.3 The specification for Safety White (a neutral) is given in Table 1. The intent of the permissible color range specified in Table 1 for Safety White is to permit greater deviation from neutral white in the red to orange to yellow hue range, and lesser deviation in the rest of the hue circle. This deviation is necessary because most white colorants are really off-whites in the red-to-yellow range. Ageing of white also results in shifts in the same direction. Because it is difficult to express this transition between chroma levels with change in hue without listing a large number of data points, users should be guided by the ovoid shown in Figure 2.

7.1.4 The colors in this Safety Color Code have been chosen to provide maximum feasible recognition by both normal and color-deficient (specifically red-green confusing) observers.

7.2 Visual test method

7.2.1 The visual specifications and test methods for daytime color are contained in the Hazardous Materials Labels and Placards Color Tolerance Charts adopted by the U.S. Department of Transportation, Research and Special Programs Administration (see reference 17).

7.2.2 Testing for compliance shall be by visual examination using visual reference standards annotated with Munsell notations, and appropriate to the color region of interest. Such standards include the Hazardous Materials Labels and Placards Color Tolerance Charts, appropriate colors from the Munsell Book of Color (reference 18), and other color samples whose values have been determined by instrumental measurement and converted to Munsell notation, provided that the restrictions of 7.2.3 are observed. Visual examination shall be conducted in accordance with ASTM D1729 (reference 19), Standard Practice for Visual Examination of Color Differences of Opaque Materials.

7.2.3 Testing for compliance by visual examination shall be limited to cases in which the specimens to be tested and the visual reference standards have similar spectral characteristics; that is, the specimens shall not be noticeably metameric to the standards as judged by ASTM D4086 (reference 20), Standard Practice for Visual Evaluation of Metamerism. If these conditions are met, the test for compliance shall be made under actual daylight or any source designated for color matching of appropriate daylight quality, and by any observer having normal color vision.

7.3 Instrumental test method

7.3.1 The instrumental color specification for each color is a set of CIE 1931 chromaticity coordinates, x,y, and luminous reflectance Y, calculated for CIE Standard Illuminant C and the CIE 1931 2° Standard Observer. These data are equivalent to the Munsell notations described in Section 7.1.1. From them are derived boundary equations defining areas in CIE color space (CIE 1931 Chromaticity Diagram) at the luminous reflectance of the standard (Y), as listed in Table 1. The permissible areas appear on Figures 1 and 2.

7.3.2 Testing for compliance can be done through the use of spectrophotometers designed to measure reflecting materials, with the data processed to yield CIE x,y,Y data for Standard Illuminant C and the CIE 1931 2° Standard Observer. The primary standard for reflectance shall be the perfect reflecting diffuser as defined by the CIE. See ASTM E1164 (reference 21) Standard Practice for Obtaining Spectrophotometric Data for Object Color Evaluation; ASTM E308 (reference 22) Standard Method for Computing the Colors of Objects by Using the CIE System; or ASTM D2244 (reference 23), Test Method for Calculation of Color Differences From Instrumentally Measured Color Coordinates.

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8 Color specifications and test methods for retroreflective materials

8.1 General

To date, instrumental test methods for measuring the daytime color of retroreflective materials have required the use of a specific colored working standard for each color, with the colorimeter being calibrated against this standard before making the measurement. Furthermore, working standards in retroreflective material matching the safety color specifications and having adequate long-term color stability are not known to exist. Without the availability of the safety colors in this medium, test methods and color specification do not currently exist.

Specifications and test methods are available for a series of six colors used by the Federal Highway Administration. It is recommended that these specifications and test methods be used because the colors are quite close to Safety Red, Safety Orange, Safety Yellow, Safety Green and Safety Blue.

8.2 Visual

The visual specifications and test methods for daytime color are contained in the Highway Color Tolerance Charts adopted by the U.S. Department of Transportation, Federal Highway Administration (see reference 17).

8.3 Instrumental

The colorimetric specifications and test methods for daytime color are contained in ASTM D 4956, *Standard for Retroreflective Sheeting for Traffic Control,* (reference 2).

9 Color specifications and instrumental test methods for fluorescent materials

9.1 General. This section provides specifications for measuring colors of fluorescent specimens as they would be perceived with the specimen illuminated by standard daylight, in terms of CIE tristimulus values and chromaticity coordinates for these conditions calculated in the CIE 1931 system.

9.2 Compliance tests. Test for compliance shall be through the use of spectrophotometers designed to measure fluorescent materials, utilizing 45/0 or 0/45 geometry in which the specimen is directly illuminated by a suitable simulator of CIE Standard Illuminant D_{65}. The data shall be processed to yield the spectral radiance factor (sum of reflected and fluoresced radiation) at the wavelength (to the nearest 10 nm) of maximum radiance factor, and CIE x,y,Y data for Standard Illuminant D_{65} and the 1931 2° Standard Observer. The primary standard for reflectance shall be the perfect reflecting diffuser as defined by the CIE. See ASTM E-991, *Standard Practice for Color Measurement of Fluorescent Specimens* (reference 24).

Two sets of specifications are provided: Those designated "restricted" are identical with the current CIE specifications for fluorescent colors for visual signaling (reference 25); they should be used when the primary consideration is the differentiation among the three fluorescent colors red, orange, and yellow, use together in a single system. The specifications designated "unrestricted" should be used when the primary consideration is the differentiation between only yellow and red-orange fluorescent colors, but it is required that these colors remain distinguishable for long periods of time (reference 26). There is only one specification for the color green.

9.3 Fundamental specifications of fluorescent safety colors. The fundamental specifications for each fluorescent safety color are given in Table 2 in terms of the equations of the boundary lines on the CIE chromaticity diagram within which the colors will fall both before and after exposure. The chromaticity coordinates of the corners of the chromaticity regions are provided in Table 3, and these regions are shown on the CIE chromaticity diagram in Figure 3. Similar regions are contained in the United States Coast Guard Specifications for fluorescent signal colors for use in long term exposure in a marine environment (reference 26). Minimum values of the spectral (total) radiance factors and luminance factors are given in Table 4.

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Table 1 – Specifications of the safety colors for CIE illuminant C (representative of overcast north sky daylight) and the CIE 1931, 2° Standard Observer

Color Names	Standard and Tolerances	Munsell Notation Specifications		Equivalent CIE Data Specifications			Boundary Equations on the CIE 1931 Chromaticity Diagram	
		Hue	Value/Chroma	x	y	Y%		
Safety Red	Standard	7.5R	4.0/14	0.5959	0.3269	12.00	Purple	y=0.4181 - 0.1700x
	Hue +	8.5R	4.0/14	0.6037	0.3389	12.00	White	y=1.1084x - 0.2892
	Hue -	6.5R	4.0/14	0.5869	0.3184	12.00	Orange	y=0.4054 - 0.1099x
	Value +	7.5R	4.5/14	0.5775	0.3320	15.57		
	Value -	7.5R	3.5/14	0.6226	0.3141	9.00		
	Chroma +	7.5R	4.0/16	0.6260	0.3192	12.00		
	Chroma -	7.5R	4.0/12	0.5603	0.3321	12.00		
Safety Orange	Standard	5.0YR	6.0/15	0.5510	0.4214	30.05	Red	y=0.2678 + 0.2545x
	Hue +	6.25YR	6.0/15	0.5452	0.4329	30.05	White	x=0.5331
	Hue -	3.75YR	6.0/15	0.5551	0.4091	30.05	Yellow	y=0.3722x + 0.2301
	Value +	5.0YR	6.0/15	0.5427	0.4206	36.20		
	Value -	5.0YR	6.5/15	0.5606	0.4218	24.58		
	Chroma +	5.0YR	5.5/15	0.5597	0.4239	30.05		
	Chroma -	5.0YR	6.0/13	0.5311	0.4154	30.05		
Safety Brown	Standard	5.0YR	2.75/5	0.4766	0.3816	5.52	Red	y=0.2317 + 0.2729x
	Hue +	7.0YR	2.75/5	0.4762	0.3981	5.52	White	x=0.4450
	Hue -	2.5YR	2.75/5	0.4728	0.3607	5.52	Yellow	y=0.1636 + 0.4926x
	Value +	5.0YR	3.25/5	0.4608	0.3801	7.71		
	Value -	5.0YR	2.25/5	0.4955	0.3826	3.82		
	Chroma +	5.0YR	2.75/6	0.5081	0.3912	5.52		
	Chroma -	5.0YR	2.75/4	0.4450	0.3720	5.52		
Safety Yellow	Standard	5.0Y	8.0/12	0.4562	0.4788	59.10	Orange	y=0.9837x + 0.0112
	Hue +	6.5Y	8.0/12	0.4498	0.4865	59.10	White	y=1.1007 - 1.4631x
	Hue -	3.5Y	8.0/12	0.4632	0.4669	59.10	Green	y=1.2183x - 0.0615
	Value +	5.0Y	8.5/12	0.4508	0.4754	68.40		
	Value -	5.0Y	7.5/12	0.4620	0.4823	50.68		
	Chroma +	5.0Y	8.0/14	0.4699	0.4920	59.10		
	Chroma -	5.0Y	8.0/10	0.4376	0.4601	59.10		

Table continued next page

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Table 1 (continued) – Specifications of the safety colors for CIE illuminant C (representative of overcast north sky daylight) and the CIE 1931, 2° Standard Observer

Color Names	Standard and Tolerances	Munsell Notation Specifications		Equivalent CIE Data Specifications			Boundary Equations on the CIE 1931 Chromaticity Diagram	
		Hue	Value/Chroma	x	y	Y%		
Safety Green	Standard	7.5G	4.0/9	0.2111	0.4121	12.00	Yellow	y=0.7598 - 1.4306x
	Hue +	0.5BG	4.0/9	0.1974	0.3809	12.00	White	y=1.8471x - 0.0417
	Hue -	5.0G	4.0/9	0.2237	0.4399	12.00	Blue	y=0.4935 - 0.5714x
	Value +	7.5G	4.5/9	0.2204	0.4060	15.57		
	Value -	7.5G	3.5/9	0.2027	0.4163	9.00		
	Chroma +	7.5G	4.0/11	0.1848	0.4319	12.00		
	Chroma -	7.5G	4.0/7	0.2350	0.3922	12.00		
	Chroma - - ††	7.5G	4.0/6	0.2467	0.3822	12.00		
Safety Blue	Standard	2.5PB	3.5/10	0.1691	0.1744	9.00	Green	y=0.8725x + 0.0457
	Hue +	4.5PB	3.5/10	0.1796	0.1711	9.00	White	y=0.2852 - 0.4696x
	Hue -	10.0B	3.5/10	0.1557	0.1815	9.00	Purple	y=1.1134x - 0.0290
	Value +	2.5PB	4.0/10	0.1805	0.1888	12.00		
	Value -	2.5PB	3.0/10	0.1576	0.1600	6.55		
	Chroma +	2.5PB	3.5/12	0.1516	0.1547	9.00		
	Chroma -	2.5PB	3.5/8	0.1888	0.1964	9.00		
Safety Purple	Standard	10.0P	4.5/10	0.3307	0.2245	15.57	Blue	y=30.8485x - 9.2485
	Hue +	2.5RP	4.5/10	0.3584	0.2377	15.57	White	y=0.4644x + 0.0869
	Hue -	7.5P	4.5/10	0.3068	0.2145	15.57	Red	y=0.8209 - 1.6273x
	Value +	10.0P	5.0/10	0.3308	0.2328	19.77		
	Value -	10.0P	4.0/10	0.3306	0.2162	12.00		
	Chroma +	10.0P	4.5/12	0.3333	0.2100	15.57		
	Chroma -	10.0P	4.5/8	0.3280	0.2391	15.57		
	Chroma - - ††	10.0P	4.5/6.5	0.3254	0.2519	15.57		
Safety White	Standard		N 9.0/	0.3101	0.3163	78.00	See Figure 2	
	Hue +			-	-			
	Hue -			-	-			
	Value +		N 9.5/	-	-	90.00		
	Value -		N 8.75/	-	-	73.40		
	Chroma +		/1.0(5R-5Y)	-	-			
			/0.5(5G-5P)	-	-			
	Chroma -		/0.0		-			

Table continued next page

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Table 1 (concluded) – Specifications of the safety colors for CIE illuminant C (representative of overcast north sky daylight) and the CIE 1931, 2° Standard Observer

Color Names	Standard and Tolerances	Munsell Notation Specifications		Equivalent CIE Data Specifications			Boundary Equations on the CIE 1931 Chromaticity Diagram
		Hue	Value/Chroma	x	y	Y%	
Safety Gray	Standard		N 5.0/	0.3101	0.3163	19.80	See Figure 2
	Hue +			-	-		
	Hue -			-	-		
	Value +		N 5.5/		-	24.60	
	Value -		N 4.5/		-	15.60	
	Chroma +		/0.5		-		
	Chroma		/0.0				
Safety Black	Standard		N1.5/	0.3101	0.3163	2.02	See Figure 2
	Hue +			-	-		
	Hue -			-	-		
	Value ++		N 2.5/**		-	4.61	
	Value +		N 2.0/		-	3.13	
	Value -		N 0.5/		-	0.58	
	Chroma +		/0.5				
	Chroma		/0.0				

NOTES

* Safety red, Safety Orange, Safety Yellow, Safety Green, Safety Blue, Safety Purple, and Safety Brown colors may be stronger (more saturated, than the C+ (plus) color as long as they comply with the hue and value tolerances. White Safety Colors may be lighter (higher value) than the V+ (plus) color, and Black Safety Colors may be darker (lower value) than the V- (minus) color as long as each complies with the applicable hue and chroma tolerances.

† The Y values in Table 1 apply to the colors of glossy or matte reflecting samples and may not be appropriate for the colors of fluorescent or retroreflective samples.

** V++ for matte Safety Blacks only. For the purpose of this standard, Matte is defined as having a 60° gloss of less than 30 (ASTM D 523).

†† Porcelain enamel only.

Table 2 – Equations of the boundary lines for the specified chromaticity regions of fluorescent safety colors illuminated by a source equivalent to CIE D_{65}, measured using 15°/0° geometry, and expressed in the CIE 1931 system.

Color	Boundary	Equation of the Boundary Line
Restricted Red	Purple White Orange	y = 0.345 - 0.051x y = 0.910 - x y = 0.314 + 0.047x
Restricted Orange	Red White Yellow	y = 0.265 + 0.205x y = 0.910 - x y = 0.207 + 0.390x
Unrestricted Red-Orange	Purple White Yellow	y + 0.345 - 0.051x y = 0.910 - x y = 0.207 + 0.390x
Restricted Yellow	Orange White Green	y = 0.108 + 0.707 y = 0.910 - x y = 1.35x - 0.093
Unrestricted Yellow	Orange White Green	y = 0.108 + 0.707x y = 0.697 - 0.547x y = 1.667x - 0.100
Green	Yellow White Blue	x = 0.313 y = 0.243 + 0.670x y = 0.493 - 0.524x

Table 3 – Chromaticity coordinates of the corners of the recommended regions of fluorescent safety colors illuminated by a source equivalent to CIE D65, measured using 15°/0° geometry, and expressed in the CIE 1931 system.

Color	1		2		3		4	
	x	y	x	y	x	y	x	y
Restricted Red	0.690	0.310	0.595	0.315	0.569	0.341	0.655	0.345
Restricted Orange	0.610	0.390	0.535	0.375	0.506	0.404	0.570	0.429
Unrestricted Red-Orange	0.690	0.310	0.595	0.315	0.506	0.404	0.570	0.429
Restricted Yellow	0.522	0.477	0.470	0.440	0.427	0.483	0.465	0.534
Unrestricted Yellow	0.522	0.477	0.470	0.440	0.360	0.500	0.412	0.587
Green	0.313	0.682	0.313	0.453	0.209	0.383	0.013	0.486

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Table 4 – Minimum permissible values of luminance factors and/or spectral (total) radiance factors, within the indicated wavelength range, of fluorescent safety colors illuminated by a source equivalent to CIE D_{65} and measured using 45°/0° geometry.

Color	Minimum luminance factor Y%	Minimum spectral radiance factor %	Wavelength range (nm)
Restricted Red	25	--	--
Restricted Orange	40	--	--
Unrestricted Red-Orange	--	100	600-630
Restricted Yellow	60	--	--
Unrestricted Yellow	--	100	520-540
Green	25	30	510-530

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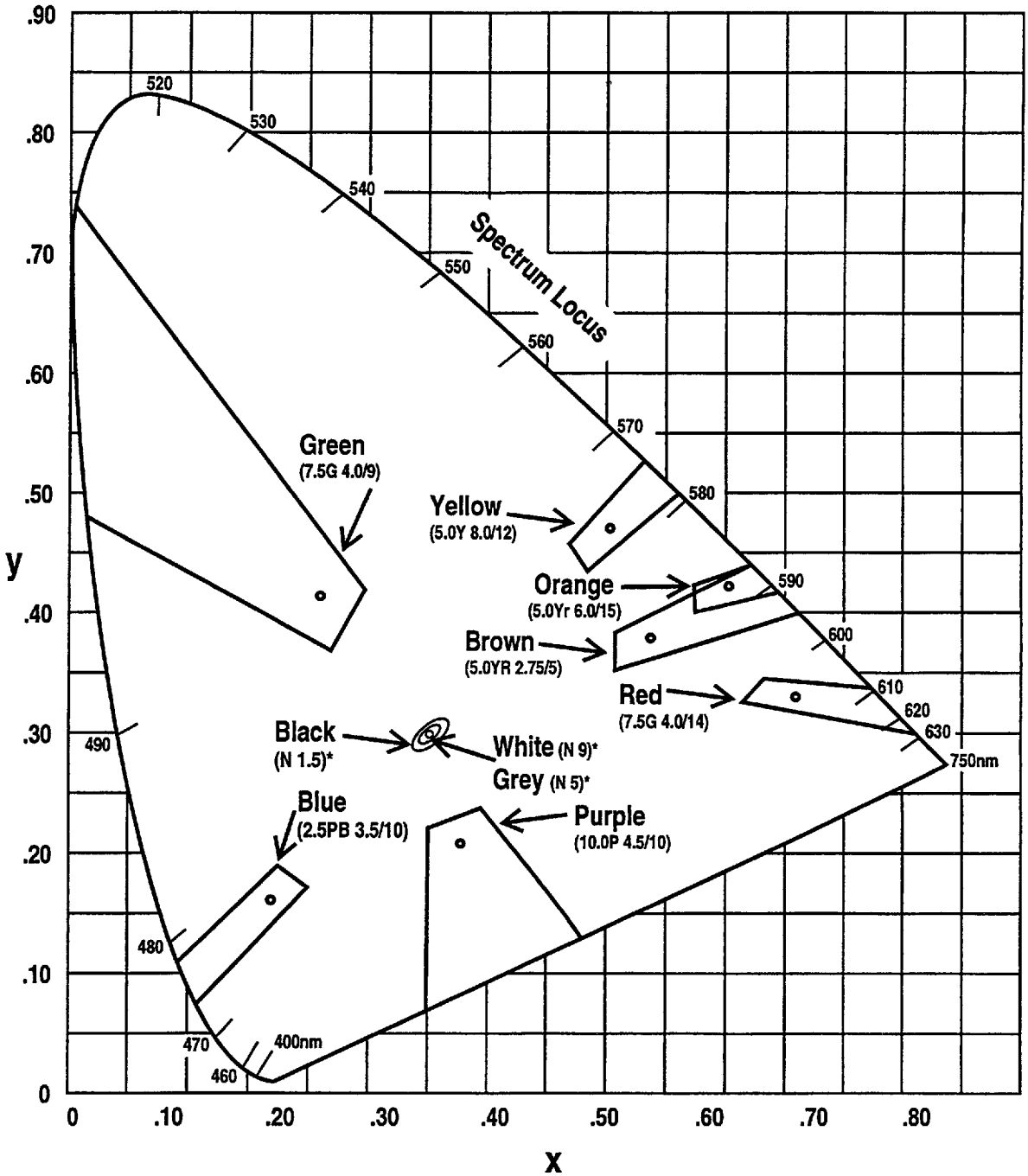

Note: The small circles inside each color limit area identifies the centroid for each color.

*See Figure 2 for an enlarged view of the white, grey and black limit areas

Figure 1 – CIE 1931 chromaticity diagram showing the areas representing the ANSI Z535.1 Safety Color Code

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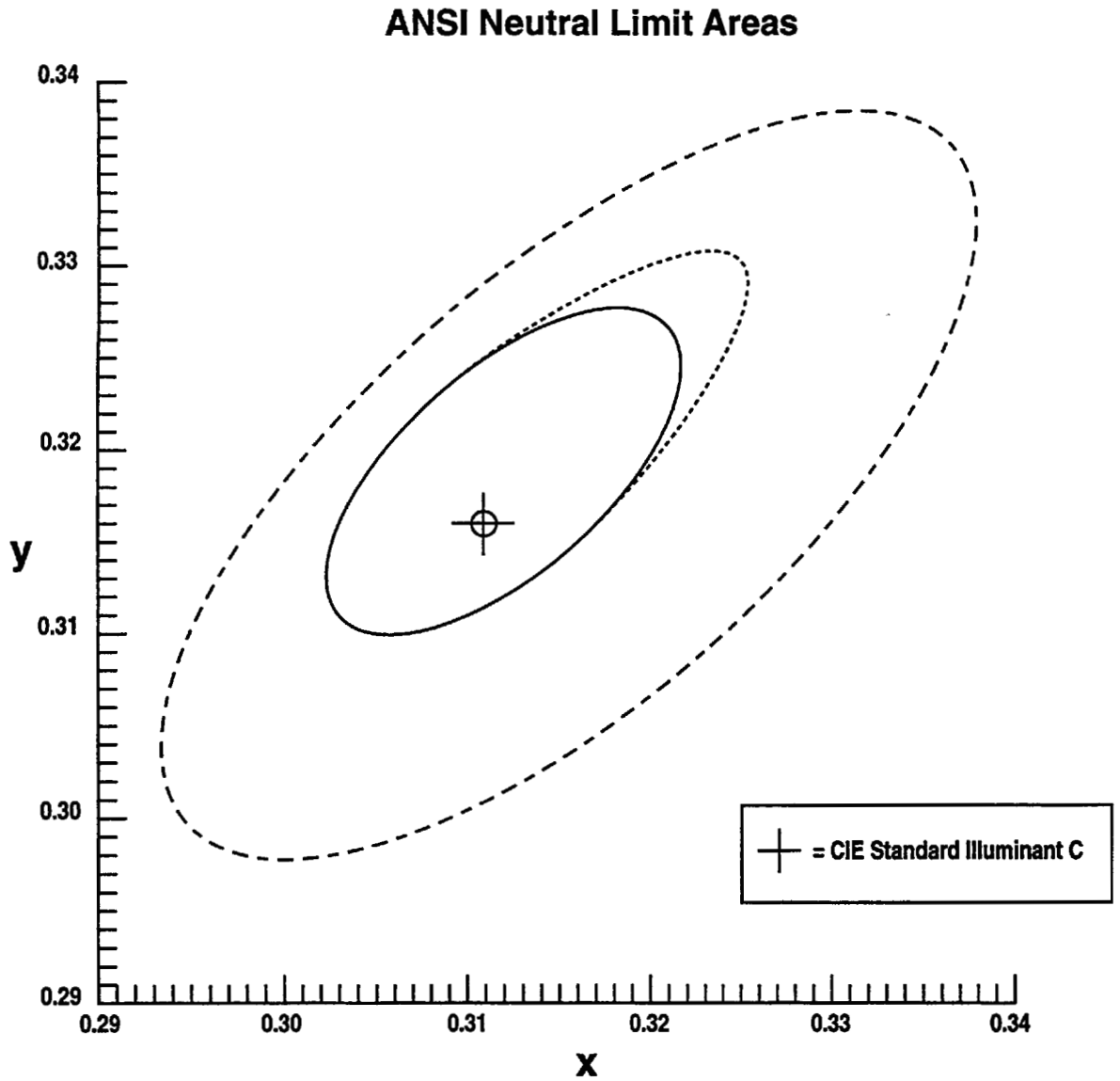

Legend	Color	Munsell Value	Munsell Chroma Tolerance
----------	White	N 9	/0.5 to /1.0
————	Grey	N 5	/0.5
- - - - - - -	Black	N 1.5	/0.5

Figure 2 – Enlarged view of the CIE 1931 chromaticity diagram showing the areas representing the ANSI Z535.1 Safety Color Code for white, grey and black

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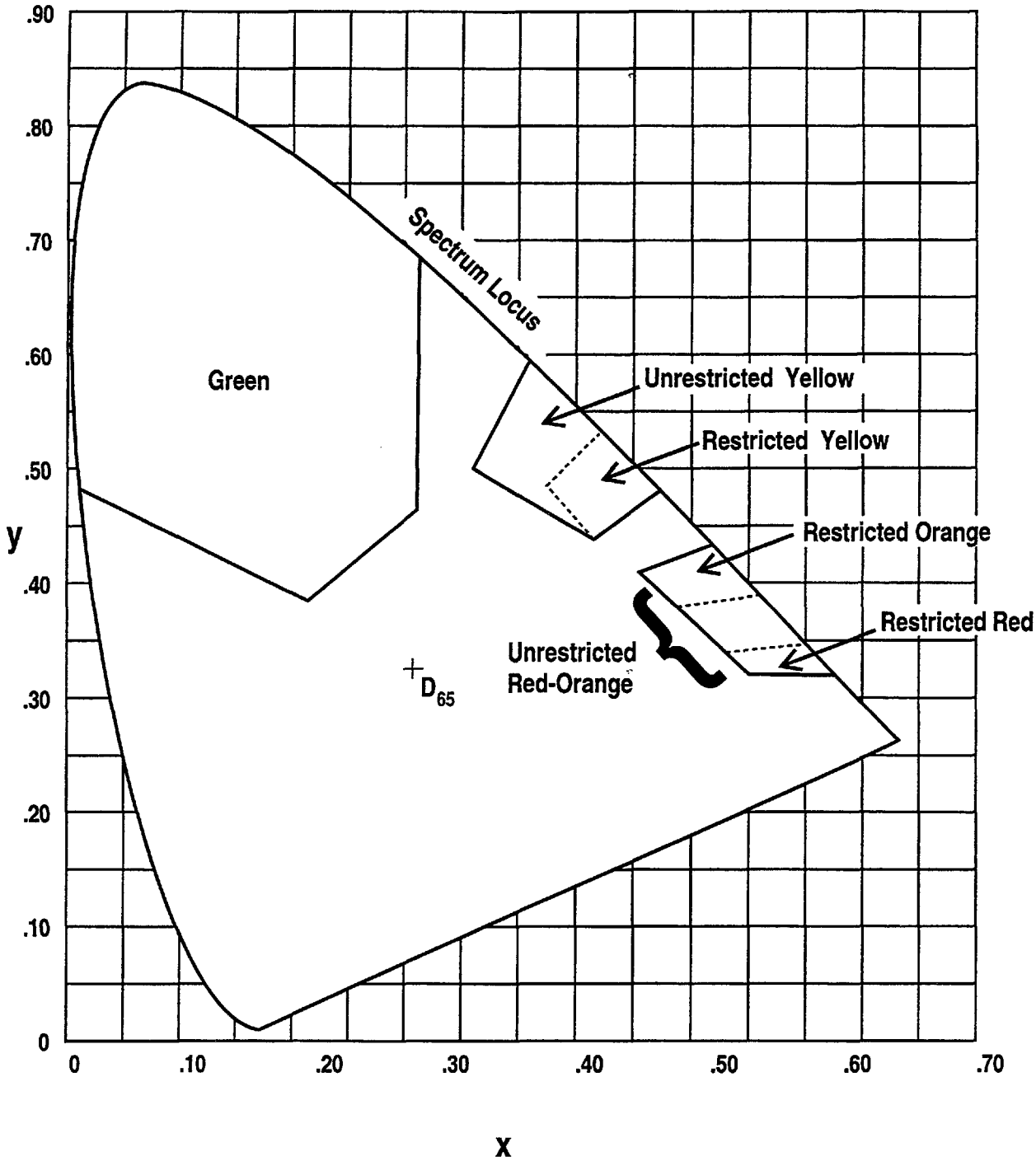

Figure 3 – CIE 1931 chromaticity diagram showing the areas representing fluorescent safety color illuminated by a source equivalent to CIE D_{65} and measured using 45°/0° geometry

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10 References

See the following documents for reference and information.

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2. *Standard Specification for Retroreflective Sheeting for Traffic Control.* ASTM D 4956-95.

3. American National Standard *Adjustable Face Vehicle Traffic Control Signal Heads.* ANSI D10. 1-1966 (R1970).

4. Railroad Transportation: *Standard Code of the Association of American Railroads — Operating Rules, Block Signal Rules, Interlocking Rules.*

5. Navigation of Waterways: United States Coast Guard - Ocean Engineering Division, Report No 37, *Visual Signaling, Theory and Application of Aids to Navigation.*

6. Air Navigation: Federal Aviation Administration — AC 70 7460-1, *Obstruction Marking and Lighting, Federal Standard No. 3.* MIL-C-25050.

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9. American National Standard *Scheme for the Identification of Piping Systems.* ANSI A13.1-1985.

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11. *Ambulance Blue and Orange.* Federal Specification KKK-A-1822, January 2, 1974.

12. American National Standard *Radio Frequency Radiation Hazard Warning Symbol.* ANSI C95.2-1982 (R 1988).

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14. *Automotive Fire Apparatus.* NFPA No. 1901-1985.

15. American National Standard *Radiation Symbol.* ANSI N2.1 1989.

16. American National Standard *Practice of Specifying Color by the Munsell System.* ANSI/ ASTM D1535-95b.

17. *Safety Color Tolerance Charts* and *Highway Color Tolerance Charts* are available from Hale Color Charts, Inc.,11765 Old Frederick Road, Marriottsville, MD 21104, Tel. 800-777-1225.

18. *Munsell Book of Color.* Munsell Laboratory, Macbeth Division, Knollmorgen Instruments Corp., 405 Little Britain Road, New Windsor, NY 12553.

19. *Standard Practice for Visual Appraisal of Colors and Color Differences of Diffusely-Illuminated Opaque Materials.* ASTM D 1729-96.

20. *Standard Practice for Visual Evaluation of Metamerism.* ASTM D 4086-92a.

21. *Standard Practice for Obtaining Spectrophotometric Data for Object Color Evaluation.* ASTM E 1164-94.

22. *Standard Practice for Computing the Colors of Objects by Using the CIE System.* ASTM E308-95.

23. *Standard Test Method for Calculation of Color Differences from Instrumentally Measured Color Coordinates.* ASTM D 2244-93.

24. *Standard Practice for Color Measurement of Fluorescent Specimens.* ASTM E 991-90.

25. Fluorescent Colours, in Publication CIE No. 39.2 (TC-1.6) 1983, *Recommendations for Surface Colours for Visual Signalling.* Currently available through the U.S. National Office of the CIE, c/o Mr. Thomas A. Lemons, TLA Lighting Consultants, Inc., 78 Pond Street, Salem, MA 01970.

26. *Fluorescent Elastomeric Films Specification No. G-EOE-339B*, April 1984, Ocean Engineering Division, U.S. Coast Guard, Washington, D.C. 20593.

27. American National Standard for *Hazardous Industrial Chemicals — Precautionary Labeling.* ANSI Z129.1-1994.

28. *Standard Specification for Retroreflective Sheeting for Traffic Control.* ASTM D4956-95.

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Annex A

(Informative)

Understanding and using the color specifications set forth in the ANSI Z535.1 Safety Color Code

This annex elaborates on the color specification information in Section 7 of this standard and is intended to be helpful to persons not familiar with basic color technology.

In science and industry, colors of products are specified in colorimetric terms. In each case it is necessary to specify a tolerance range for a color since it is seldom possible to exactly match a specified color. In color-intensive industries such as paint, textiles, plastics, ceramics and printing, color measuring instruments are ordinarily used to determine if a product's color is within a specification. These instruments are expensive and require a trained operator, though when used frequently, their expense is justified.

Many industries only occasionally need to comply with a color specification and in such cases the expense of an instrument and a trained operator is difficult to justify. For such applications color tolerance charts are often used to display the ideal color and examples of tolerances around it. Color samples are visually compared to such charts to determine compliance with colorimetric specifications. Thus, it is possible to have both instrumental and visual test methods to determine color conformance.

In ANSI Z535.1, Table 1 and Figures 1 and 2 provide specification data. Figure 1 is a CIE xy chromaticity diagram. This diagram is essentially a "color map" upon which are plotted the ideal safety colors and their tolerance regions. Figure 2 is an enlarged view of the central portion of Figure 1 that makes it easier to plot the neutral colors (white, gray and black). In Figure 1, the horseshoe-shaped perimeter is called the spectrum locus and along its outer boundary lie the most vivid versions of each safety color. Wavelength numbers appear just outside this locus. It is not currently possible to produce opaque colors vivid enough to fall on the spectrum locus, though we can achieve these positions with colored lights.

Within each permissible color region in Figure 1 is a circle denoting the position of the ideal, or Standard Color. These are the colors defined in Table 1 of this standard. For each color region there is a range of hue defined by the lines extending to the spectrum locus, plus a line connecting these two toward the center of the diagram which represents the boundary of minimum saturation. You can duplicate these plots by solving the linear equations in Table 1 (Boundary Equations) and plotting the resulting xy data pairs on graph paper.

To instrumentally test a colored sample you need to measure it on a spectrophotometer and then compute the data for CIE Illuminant C and the CIE 1931 2° Standard Observer. These computations are made automatically once the computer menu is programmed accordingly. The instrumental result in terms of Yxy data are recorded. Plot x and y on the xy diagram, and if this data point is within the boundary, the chromaticity is satisfactory. The capital Y value is compared with the range of Y values in Table 1 under "Specification" and "CIE Data." If the color is neutral (white, gray or black) use Figure 2 for plotting the xy data.

The visual test method differs from the instrument one because people see colors differently from how instruments measure colors. However both methods give related results, though the instrumental results are more accurate. The actual color tolerances for each Safety Color are quite liberal so the inaccuracy inherent in the visual test method is seldom a problem.

Figure 5 is an example showing how the color specification test methods are used in practice. This illustration is an enlargement of the xy chromaticity diagram region for Safety Yellow – the solid square corner points are the same as the corner points for this color in Figure 1. For convenience the spectrum locus, the red and green boundary lines, and the minimum saturation boundary are also identified.

The solid circles identify points along the red, green and low saturation boundaries and there is a "HIGH CHROMA" color which is a typical color more vivid than the ideal or standard color. Examples of high chroma (saturation) colors appear on color tolerance charts for orientation purposes.

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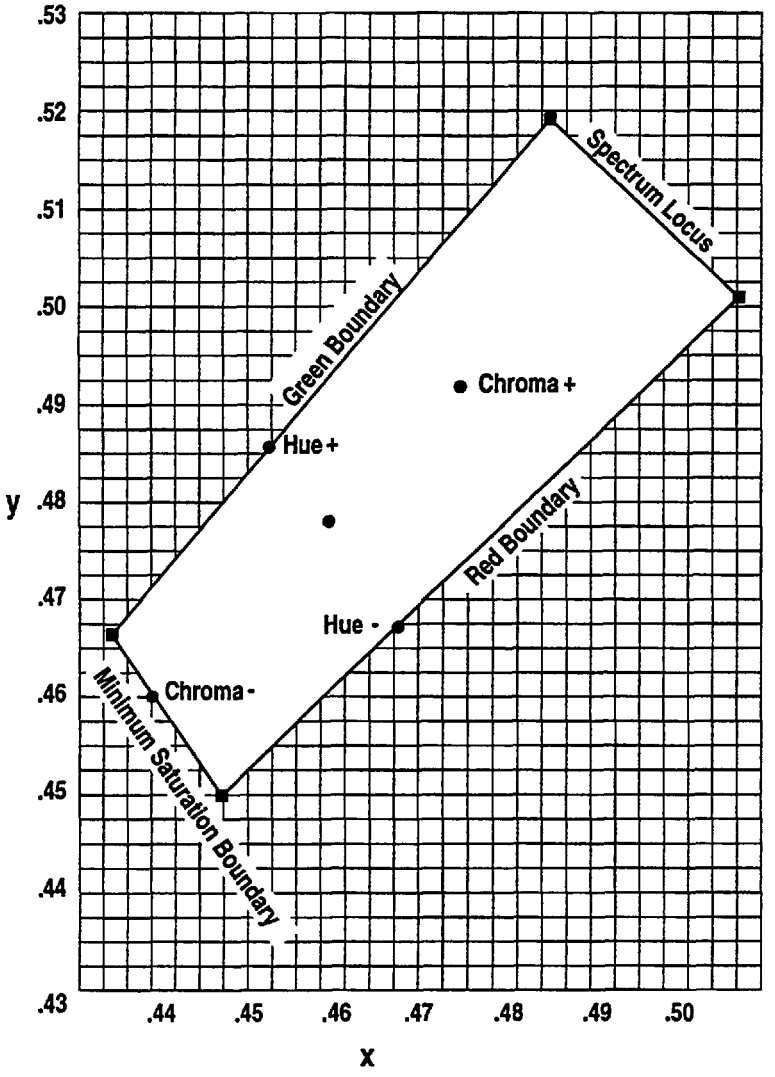
Data points shown as solid circles in Figure 5 represent colors which appear on a color tolerance chart for Safety Yellow. These data points are also found in Table 1 and are identified by their xy data, their Munsell notations and their standard or tolerance designation.

The RED LIMIT H- color on Figure 5 is shown in Table 1 as Safety Yellow Hue- and has a Munsell notation of 6.5Y 8.0/12. Visually it is clearly redder than the Standard Safety Yellow Color (5.0Y 8.0/12). All colors falling along the Red Boundary will have the same visual hue as this Red Limit, permitting the observer to determine if a color sample is too red or visually between the Standard Safety Yellow Color and the Red hue limit. To compare a sample color with a color tolerance chart, the sample is placed under the cutout portion of the chart and viewed in daylight. A visual determination can then be made to see if the sample color falls within the chart's visual color tolerances.

When a Yellow color sample is compared with the Standard Safety color on a Yellow color tolerance chart, it will either be seen as a good match or as redder or greener. If it is redder or greener than the standard color, the sample is then compared to the appropriate tolerance color too see if it falls within the permissible range of color. The same is true with respect to the saturation minimum (C-) and to the light and dark limit colors. If the sample color is visually between each pair or limits shown in the color tolerance chart, and more saturated than the C- color shown on the chart, the sample complies with the specification.



This diagram shows the relationship between the permissible color region for Safety Yellow as shown in Figure 1 tolerance limits for Safety Yellow described in the CIE data found in Table 1.

■ = Corner Points of Acceptable Color Tolerance Region

● = Color Tolerance Chart Colors

Figure 5 – Enlarged view of CIE 1931 chromaticity diagram showing the areas representing the Color Tolerance Area for ANSI Z535.1 Safety Yellow

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Revisions 2001

The ANSI Accredited Standards Committee Z535 plans to issue the next revisions of the Z535 Standards (.1 through .5) in December 2001. In order to meet that deadline, the committee developed the following tentative timetable:

All proposed changes are due:	June 30, 1999
Revisions will be finalized for letter balloting:	April 11, 2000
Letter balloting will be completed by:	July 18, 2000
Public reviews will be completed by:	March 1, 2001
Drafts will be ready to submit to the publisher:	May 21, 2001
Published:	December 15, 2001

All proposed changes must be submitted by June 30, 1999. Any proposals received after that date will be deferred to subsequent revisions. In order to facilitate the next revision, proposed changes must be submitted on a form for that specific purpose, which is on the back of this page. Please send this form to:

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National Electrical Manufacturers Association
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Rosslyn, VA 22209

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ANSI Accredited Standards Committee Z535
On Safety Signs and Colors

FORM FOR PROPOSALS

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1. a. Standard Title_____

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2. Proposal recommends (check one): New Text
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3. Proposal (Include the proposed new or revised text, or identify the words to be deleted.)

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