NEMA EM 1

Exit Sign Visibility Testing and Requirements for Safety

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NEMA Standards Publication EM 1-2002

Exit Sign Visibility Testing and Requirements for Safety

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Foreword

The purpose of this NEMA Standards Publication is to promote safety by setting forth visibility testing procedures and requirements for exit signs. These procedures and requirements are based on the best available objective research by the National Institute of Standards and Technology and the Lighting Research Center and on independent testing by CSA International. For the purposes of this standard, the function of an exit sign is regarded as two-fold, for readability and to attract attention in an emergency situation.

This standard is based largely on the work done by CSA International and participating companies and organizations in developing CSA Standard C860-01, *Performance for Internally Lighted Exit Signs*. However, this NEMA Standards Publication is not intended for listing or certification of products covered its scope. For listing and certification purposes, consult the appropriate publications of Underwriters Laboratories Inc. and/or CSA International.

In the preparation of this standards publication, input of users and other interested parties was sought and evaluated. Inquiries, comments, and proposed or recommended revisions should be submitted to the Emergency Lighting Subdivision of NEMA by contacting:

Vice President, Engineering
National Electrical Manufacturers Association
1300 North 17th Street, Suite 1847
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The Emergency Lighting Section developed this standard. Section approval of the standard does not necessarily imply that all section members voted for its approval or participated in its development. At the time the standard was approved, the Emergency Lighting Section was comprised of the following members:

Cooper Lighting

Genlyte Thomas Group, LLC

Gilbert Industries, Inc.

Hubbell Incorporated

Lighting Corporation of America

Lithonia Lighting

The Bodine Company, Inc.

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1 Scope

This standards publication contains performance requirements and test methods for evaluating exit sign visibility. Visibility requirements are based on an assumed normal visual acuity and normal color recognition in clear air at a maximum viewing distance of 30.5 m (100 ft) This scope does not imply that exit signs conforming to the requirements of this standard will be visible to all people under all environmental conditions.

These requirements apply to exit signs that illuminate an integral legally required legend for installation in accordance with the *National Electrical Code* (ANSI/NFPA 70) and the *Life Safety Code* (ANSI/NFPA 101), including exit signs intended for use near the floor.

2 Definitions

2.1

chevron, or directional indicator
A graphical symbol used in conjunction with a legend on an exit sign to indicate a preferred direction of egress.

2.2

edgelit sign
A type of exit sign, in which the light from an enclosed light source is directed through a light-transmitting plate that has the legend etched in or attached to its surface. The sign face appears luminous when light leaves disruptions in the plate.

2.3

exit sign
A device used in buildings to identify the most direct path of egress for emergency purposes. It contains a legend and optional directional indicator(s). The exit sign is considered to be internally illuminated if the legend and optional directional indicator or background, or both, are illuminated by a light source contained within the assembly supporting the legend and optional directional indicator.

2.4

legend
The word or words required to be contained on an exit sign.

2.5

legibility
The attributes of alphanumeric characters, including contrast, luminance, stroke width, and shape, that make it possible for each one to be distinguished and identified.

2.6

visibility
The quality of a character or of a symbol that makes it detectable from its surroundings.

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3 Referenced publications

The following standards contain provisions that through reference in this standard constitute applicable requirements. Since standards are subject to revision, the latest editions are to be consulted.

Canadian Standards Association
5060 Spectrum Way
Mississauga, Ontario L4W 5N6 Canada

CAN/CSA C22.2 No. 141-02: *Unit Equipment for Emergency Lighting*

CSA C860-01: *Performance of Internally Lighted Exit Signs*

Underwriters Laboratories Inc.
333 Pfingsten Road
Northbrook, IL 60062

UL 924, Standard for Safety: *Emergency Lighting and Power Equipment*

4 General requirements

4.1 Luminosity of elements and legend

Lighted elements and/or the legend of exit signs shall be uniformly luminous across their entire height, width, and stroke width.

4.2 Legends

4.2.1 General

The legend shall contain all uppercase sans serif characters that are 150 mm (6 in.) or greater in height. An angle may be rounded off with a radius not to exceed 2.54 mm (0.1 in.) if that angle is 90° or less. The measurement of the aspect ratio at the rounded corners shall be taken at the intersection of the extrapolated straight lines. The extrapolation of lines need not be considered when measuring the distances between characters.

4.2.2 Aspect ratios of characters

The aspect ratios, or the ratios of letter height to width, width to stroke width, and stroke width to inter-character spacing, shall be as specified in Table 1. Measurement of the overall character dimensions shall include any illuminated borders, or in the case of reduced size illuminated legends, the non-illuminated, opaque borders of the illuminated characters.

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Table 1 – Aspect ratios for legend characters

Relationship	Letters	Ratio
Stroke width to inter-character spacing [a]	All	2:1
Stroke width to interline spacing	All	<= 2:1
Height to width	All	2.6:1 to 3:1
Width to stroke width	All	2.6:1 to 3.3:1

[a] Except for letter "l," which shall have a minimum width of 19 mm (0.75 in).

4.3 Chevrons

4.3.1 Shape

A directional indicator, or chevron, if provided on an exit sign, shall be of the shape shown in Figure 1. Corners of the chevron may be rounded with a radius not to exceed 1.5 mm (0.060 in.).

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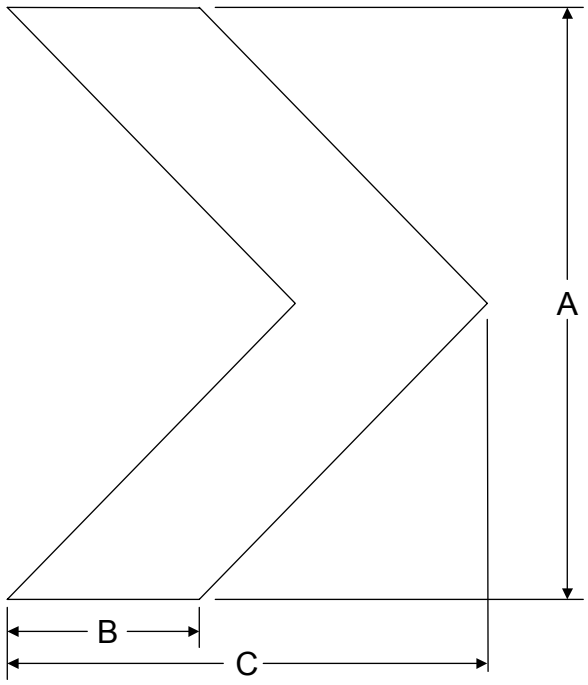

Directional indicator number	Minimum dimensions					
	A		B		C	
	mm	inches	mm	inches	mm	inches
1	31.8	1.25	10.6	0.42	26.5	1.04
2[a]	---	Any size > 1.25	---	Any size > 0.42	---	Any size > 1.04

[a] Size must be proportionally larger as indicated:

Relationship	Ratio
height : width	1.2 : 1 maximum
height : horizontal stroke width	3 : 1 maximum

Figure 1 – Directional indicator

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4.3.2 Size

The chevron shall not be less than 32 mm (1.25 in.) in height. The height to width and height to stroke width ratios are specified in Table 2. The critical dimensions for the height, width, and stroke width shall be measured from the outermost edge of any outline defining the shape of the chevron. For the measurement of the aspect ratio, the measurement shall be taken at the intersection of the extrapolated straight lines at the rounded corner.

Table 2 – Aspect ratios for chevrons

Relationship	Ratio
Height to width	<= 1.2:1
Height to stroke width	<= 3:1

4.3.3 Location

If a chevron is part of an exit sign, the exit sign shall be constructed so that:

- The chevron is located outside of the legend.
- It is not less than 9.5 mm (.375 in.) from any character.
- It is centered vertically on the legend.
- It is on the same side of the legend as the intended direction of egress; that is on the right side pointing right, on the left side pointing left, or on each side of the legend, if appropriate. See Figure 2.

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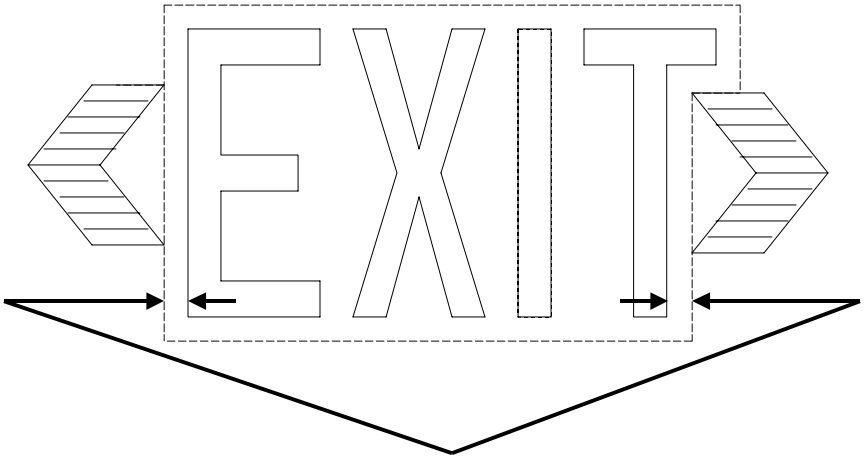

Figure 2 – Minimum distance between directional indicator and legend

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4.4 Luminous background

The distance between the outermost edge of any outline defining the shape of a character or chevron and the outermost edge of the luminous background shall be greater than or equal to 19 mm (.75 in.) for exit signs with luminous backgrounds.

5 General test and equipment requirements

5.1 Ambient conditions

All testing shall be performed at an ambient temperature of 25 ± 5°C.

5.2 Energizing the exit sign

5.2.1

The sign shall be energized from the normal supply at rated voltage for at least 100 hr before testing procedures begin. For signs using separate light sources for the emergency mode, there shall be no seasoning required for the emergency illuminants.

5.2.2

Immediately prior to testing, the exit sign shall be energized for a time period specified by the manufacturer, but for greater than or equal to 20 min, under the required test conditions.

5.3 Power supplies

5.3.1 AC power supply

The voltage supplied to the sign or to an energizing light source by an AC regulated power supply shall have a wave shape such that the root mean square (rms) of the harmonic components does not exceed 5% THD. The supply voltage shall be regulated to within ± 0.5% of the test voltage. Frequency shall be 60 Hz.

5.3.2 DC power supply

The voltage supplied to the exit sign by a constant-voltage dc power supply shall be regulated to within ± 0.5% of the test voltage.

5.4 Test instruments

5.4.1 Calibration and read-out

All instruments shall be recently calibrated to a traceable standard at the National Institute of Standards and Technology, or a recognized equivalent. Instruments with digital readouts are preferred. If analog instruments are used, the readout shall be within the upper one-third of the scale used.

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5.4.2 Photometers

5.4.2.1

Photometers used for measuring illuminance or luminance shall be color-corrected according to the 1931 CIE Spectral Luminous Efficiency (Vλ) Curve. The photometer shall not deviate from the V(λ) function by more than 3%, as given by the CIE error term f_1', and shall have a value of $f_2(u)$ of less than or equal 5% when measured in accordance with CIE Technical Report 69. The photometric instrument is considered to be suitably corrected to the V(λ) function if it is calibrated against another photometer having an f_1' of 3% or less and the calibration is performed using the same spectral distribution (from the combined lamp, sign panels, and ambient lighting when present) as that to be measured during the test.

5.4.2.2

Photometers shall have an accuracy of ± 5% or better.

5.4.2.3

The photometer shall be cosine-corrected if it is intended to be used for measuring illuminance.

5.4.3 Electrical instruments

Ammeters and voltmeters shall have an accuracy of ± 0.5% or better up to 800 Hz. Wattmeters shall have an accuracy of ± 0.75% or better up to 800 Hz. True rms meters shall be used to measure rms values.

6 Luminance requirements

6.1 Exit Signs in the non-energized state

6.1.1 Test conditions

The sign shall not be energized and the face of the sign shall be externally illuminated to 100 lx, in accordance with clause 7.2.

6.1.2 Luminance uniformity within the legend

The ratio of the maximum luminance to the minimum luminance for the individual measurement points on all of the characters and chevrons, if provided, shall be less than or equal to 1.4:1, when determined in accordance with clause 7.3.

6.1.3 Luminance uniformity across the background

The ratio of the maximum luminance to the minimum luminance for individual measurement points on the background shall be less than or equal to 1.4:1, when determined in accordance with clause 7.4.

6.1.4 Luminance contrast

The luminance contrast of both legend and chevron(s) with the background shall be greater than or equal to 0.50:1, when calculated in accordance with clause 8.1.

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6.1.5 Luminance contrast of concealing mechanisms for unused chevrons

If an exit sign is provided with a mechanism for choosing one of two available chevrons during installation, there shall be a means of concealing the unused chevron. If the concealing means has a shape that can be confused with the shape of a chevron, the contrast ratio of the concealing means and the adjacent background shall be less than or equal to 0.1:1, when calculated in accordance with clause 8.1. An outline of less than 0.5 mm (.02 in.) in width shall be exempt from these requirements.

6.2 Exit signs using normal AC power

6.2.1 Test conditions

The sign shall be energized by a regulated power supply adjusted to the rated voltage for normal operation. The face of the sign shall be externally illuminated to 0 lx for luminance measurements, except as specified in Table 3 and clause 6.2.4. When specified in Table 3, energized signs shall be externally illuminated in accordance with clause 7.2.

6.2.2 Luminance uniformity within legends and chevrons

6.2.2.1 Luminous legends and chevrons

The ratio of the maximum luminance to the minimum luminance for the individual measurement points on all of the characters and chevron(s) that are internally lighted shall be less than or equal to 20.0:1, when determined in accordance with clause 7.3.

6.2.2.2 Non-luminous legends and chevrons

When the sign is externally illuminated, the ratio of the maximum luminance to the minimum luminance for the individual measurement points on all of the characters and chevron(s), which are not internally lighted, shall be less than or equal to 2.0:1, when determined in accordance with clause 7.3.

6.2.3 Luminance uniformity across the background

6.2.3.1 Luminous backgrounds

When energized, the ratio of the maximum luminance to the minimum luminance on a background that transmits more than 1 cd/m^2 shall be less than or equal to 20.0:1, when determined in accordance with clause 7.4. Also, see Figure 3.

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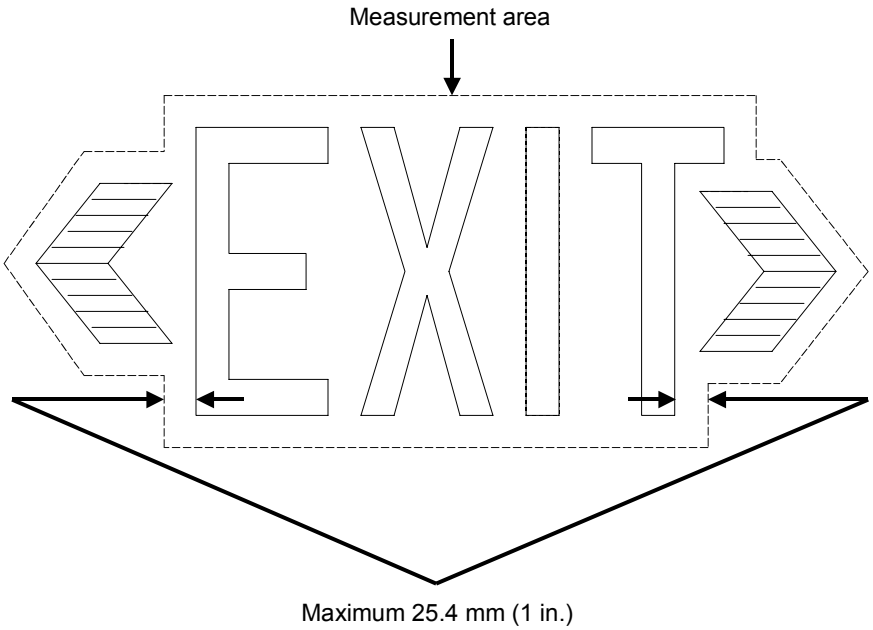

Figure 3 – Measurement area for an exit sign with a translucent background

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6.2.3.2 Non-luminous backgrounds

When energized, the ratio of the maximum luminance to the minimum luminance on a background that transmits less than 1 cd/m^2 shall not require testing to the requirements of clause 6.2.3.

6.2.4 Luminance contrast

6.2.4.1

The minimum luminance contrast of both the legend and the chevron(s) with the background shall comply with Table 3, when calculated in accordance with clause 8.1. Determination of contrast ratio is not required when all measured points on the background are less than 1 cd/m^2.

6.2.4.2

Edgelit signs shall be tested at both ambient conditions. When testing edgelit signs at 0 lx, the background shall be black, with a reflectance of + 5% and a gloss of 0 to 5%. When testing edgelit signs at 50 lx, the background shall be white, with a reflectance of 85 $\pm$ 5% and a gloss of 0 to 5%.

6.2.4.3

Signs with colored legends and achromatic backgrounds are exempt from testing at ambient lighting conditions of 50 lx.

NOTE—Silvery metals such as brushed aluminium can be considered achromatic. Yellowish metals such as brass and copper cannot be considered achromatic.

Table 3 – Luminance contrast

Type of sign	Ambient light	Minimum contrast ratio
Legend or background opaque	50 lx	0.25
Legend and background luminous	0 lx	0.50
Edgelit	50 lx	0.25
	0 lx	0.50

6.2.5 Minimum luminance of a luminous element

6.2.5.1

If the legend is luminous and the background is opaque, the mean luminance and the uniformity of the legend shall comply with Figure 4, with a minimum mean luminance value of 15 cd/m^2, when determined in accordance with clause 7.3. In addition, each individual measured luminance value shall be greater than or equal to 8.6 cd/m^2.

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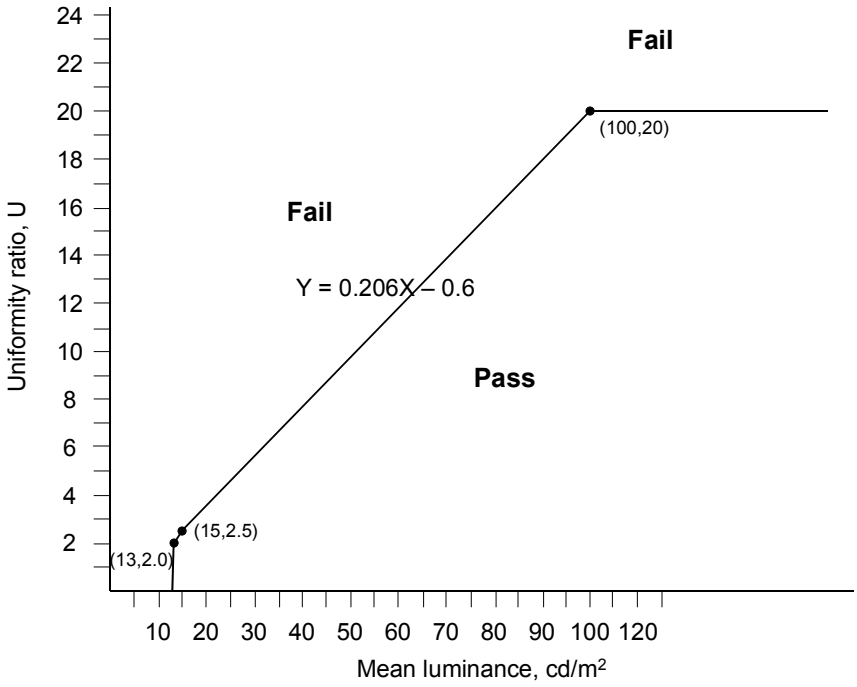

Figure 4 – Minimum mean luminance vs. uniformity ratio

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6.2.5.2

If the background is luminous and the legend is opaque, the mean luminance and uniformity of the background shall comply with Figure 4, with a minimum mean luminance value of 15 cd/m^2, when determined in accordance with clause 7.4. In addition, each individual measured luminance value shall be greater than or equal to 8.6 cd/m^2.

6.2.5.3

If both the background and the legend are luminous, the brightest element, either the background or the legend, shall comply with clause 6.2.5.1 or 6.2.5.2, as appropriate.

6.3 Exit signs using emergency DC power

6.3.1 Test conditions

6.3.1.1

For test purposes, the sign shall be energized by a constant-voltage DC power supply, adjusted to a DC voltage equal to:

a) The voltage of the fully charged battery, one minute after the discharge is initiated.

b) The measured battery voltage at the end of a rated duration discharge, if the battery is supplied with the sign; OR

c) 87.5% of the rated battery voltage if the battery is not provided.

6.3.1.2

The face of the sign shall be externally illuminated to 0 lx for luminance measurements, except as specified in Table 3 and clause 6.3.4. When specified in Table 3, energized signs shall be externally illuminated in accordance with clause 7.2.

6.3.2 Luminance uniformity within legends and chevrons

6.3.2.1 Luminous legends and chevrons

The ratio of the maximum luminance to the minimum luminance for the individual measurement points on all of the characters and chevron(s) that are internally lighted shall be less than or equal to 20.0:1, when determined in accordance with clause 7.3.

6.3.2.2 Non-luminous legends and chevrons

When the sign is externally illuminated, the ratio of the maximum luminance to the minimum luminance for the individual measurement points on all of the characters and chevron(s), which are not internally lighted, shall be less than or equal to 2.0:1, when determined in accordance with clause 7.3.

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6.3.3 Luminance uniformity across the background

6.3.3.1 Luminous backgrounds

The ratio of the maximum luminance to the minimum luminance for the individual measurement points on the background that are internally lighted shall be less than or equal to 20.0:1, when determined in accordance with clause 7.4. Also, see Figure 3 and clause 6.2.3.1.

6.3.3.2 Non-luminous background

The ratio of the maximum luminance to the minimum luminance for the individual measurement points on the background that are not internally lighted shall be less than or equal to 2.0:1, when determined in accordance with clause 7.4. This requirement does not apply to backgrounds with luminance less than 1 cd/m^2.

6.3.4 Luminance contrast

6.3.4.1

The minimum luminance contrast of both the legend and the directional indicator(s) with the background shall comply with Table 3, when calculated according to clause 8.1. Determination of contrast ratio is not required when all measured points on the background are less than 1 cd/m^2.

6.3.4.2

Edgelit signs shall be tested at both ambient conditions. When testing edgelit signs at 0 lx, the background shall be black, with a reflectance of + 5% and a gloss of 0 to 5%. When testing edgelit signs at 50 lx, the background shall be white, with a reflectance of 85 $\pm$ 5% and a gloss of 0 to 5%.

6.3.4.3

Signs with colored legends and achromatic backgrounds are exempt from testing at ambient lighting conditions of 50 lx.

NOTE—Silvery metals such as brushed aluminium can be considered achromatic. Yellowish metals such as brass and copper cannot be considered achromatic.

6.3.5 Luminance contrast of concealing mechanisms for unused directional indicators

If an exit sign is provided with a mechanism for choosing one of two available directional indicators during installation, there shall be a means of concealing the unused directional indicator. If the concealing means has a shape that can be confused with the shape of a directional indicator, the contrast ratio of the concealing means and the adjacent background shall be less than or equal to 0.1:1, when calculated in accordance with clause 8.1. An outline of less than 0.5 mm (.02 in) in width shall be exempt from these requirements.

6.3.6 Minimum luminance of a luminous element

6.3.6.1

If the legend is luminous and the background is opaque, the mean luminance and uniformity of the legend shall comply with Figure 4, with a minimum mean luminance value of 15 cd/m^2 for condition a of clause 6.3.1.1 and 13 cd/m^2 for condition b or c of clause 6.3.1.1, when determined in accordance with clause 7.3. In addition, each individual measured luminance value shall be at least 8.6 cd/m^2.

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6.3.6.2

If the background is luminous and the legend is opaque, the mean luminance and uniformity of the background shall comply with Figure 4, with a minimum mean luminance value of 15 cd/m^2 for condition a of clause 6.3.1.1 and 13 cd/m^2 for condition b or c of clause 6.3.1.1, when determined in accordance with clause 7.4. In addition, each individual measured luminance value shall be at least 8.6 cd/m^2.

6.3.6.3

If both the background and the legend are luminous, the brightest element, either the background or the legend, shall comply with clause 6.3.6.1 or 6.3.6.2, as appropriate.

7 Luminance measurements

7.1 General

For test purposes, the exit sign shall be centrally mounted on a rectangular vertical surface painted flat black that has a nominal height and width of 1.0 m (40 in.).

7.2 Illuminance apparatus

7.2.1

The face of the sign shall be externally illuminated by two lamps located in a plane that is normal to the face of the sign and passes through the geometric center of the legend. The lamps shall be located within the defined plane, at equal radial distances from the geometric center of the legend and 45° from the normal to the sign face. The lamps shall be aimed at the geometric center of the legend. See Figure 5.

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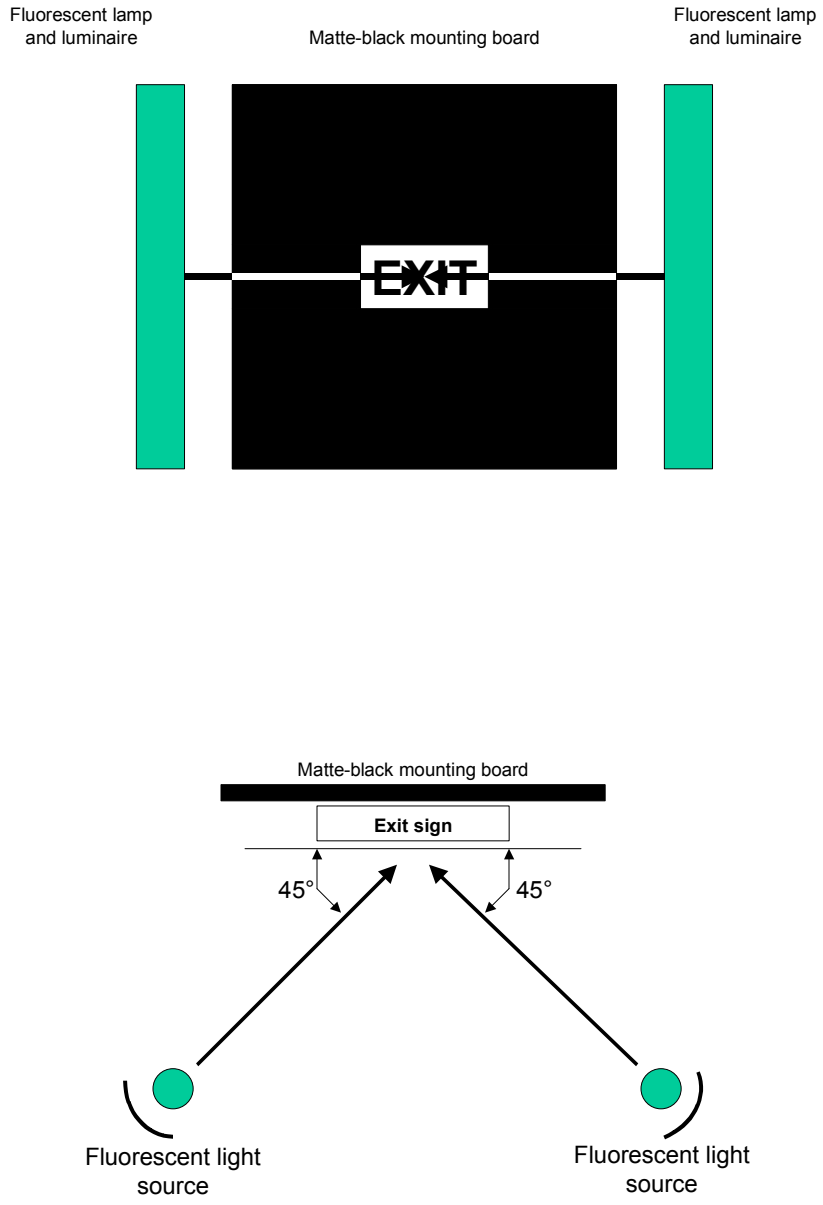

Figure 5 – Illuminance test apparatus

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7.2.2

The lamps shall be fluorescent and shall be mounted vertically in a strip-fluorescent fixture. Both lamps shall be produced by the same manufacturer and shall be identical in their physical, electrical, and color attributes. The lamps shall have a correlated color temperature of 4100 K and a minimum color rendering index (CRI) of 70. The minimum radial distance from the lamps to the sign face shall be 1 m (40 in.). Both lamps shall be regulated by one two-lamp, dimming ballast, powered from a regulated AC supply. The lamps shall be shielded from directly illuminating the luminance meter used to measure the sign luminance.

7.3 Luminous legend and chevron

7.3.1

The luminance of the legend and chevron(s) of an exit sign shall be measured in units of cd/m^2. Luminance shall be measured for circular areas located at the points shown in Figure 6 or 7 for testing in the non-energized state, and Figure 8 or 9 for testing in the energized state, as appropriate.

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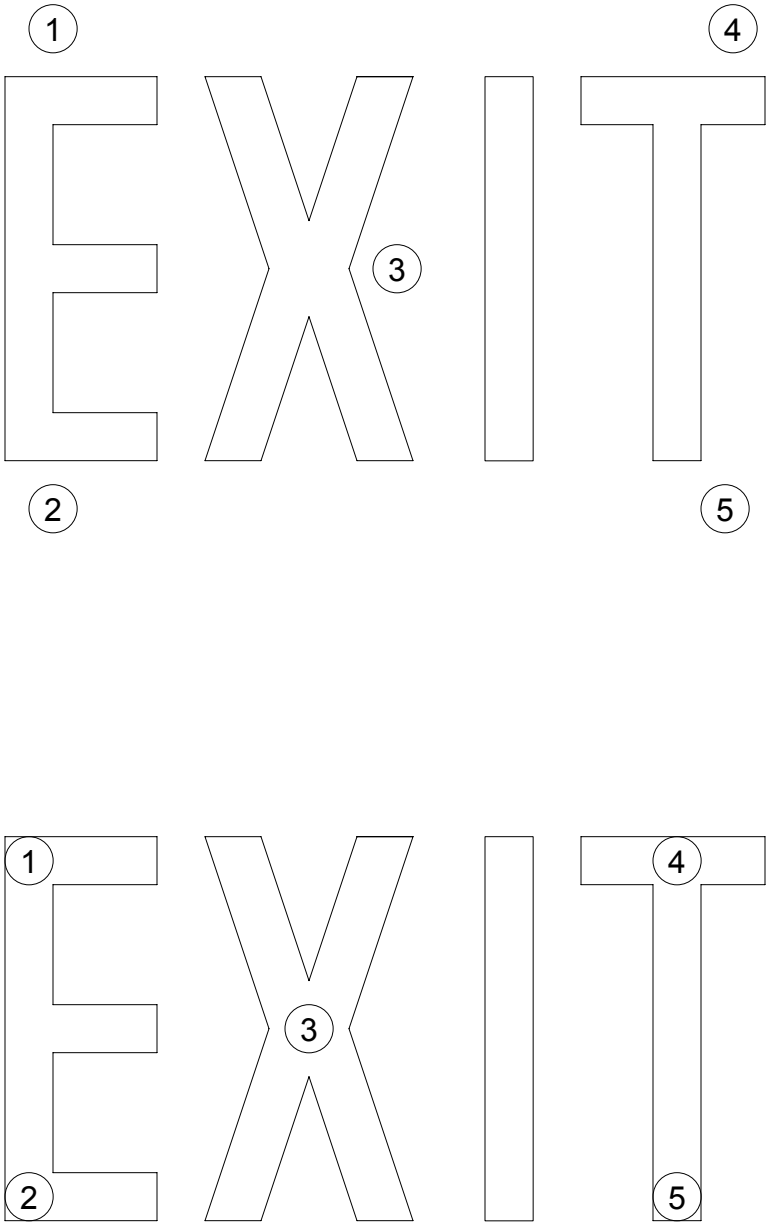

Figure 6 – Luminance measurement points for EXIT legend, non-energized state

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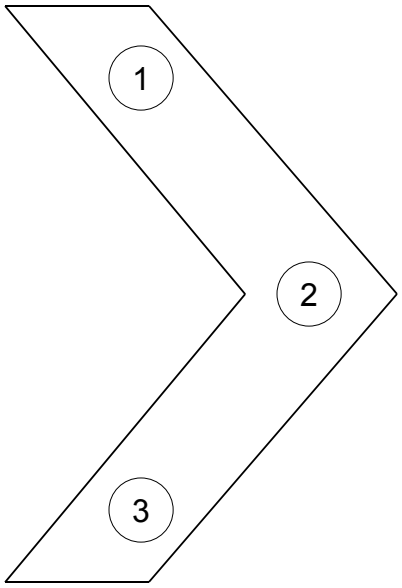

Figure 7 – Luminance measurement points for the chevron, non-energized state

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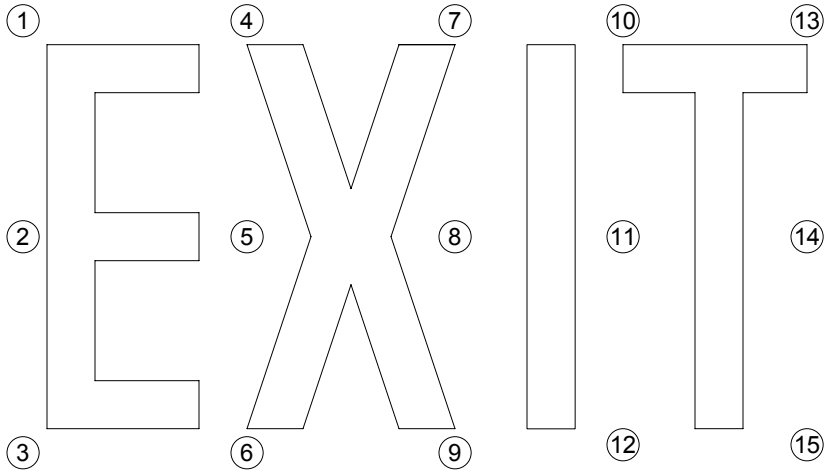

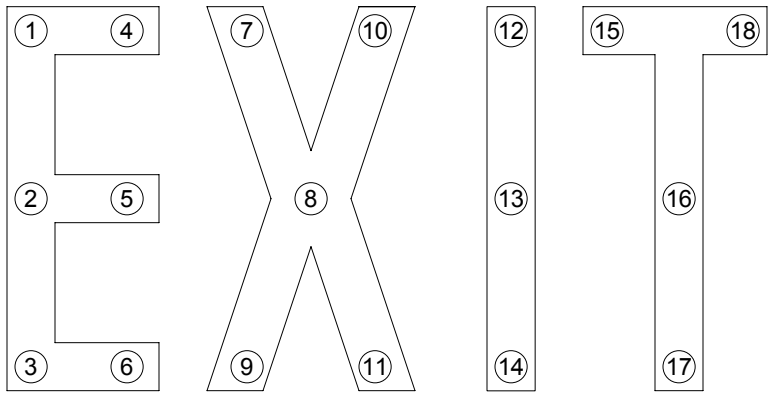

Figure 8 – Luminance measurement points for EXIT legend, energized state

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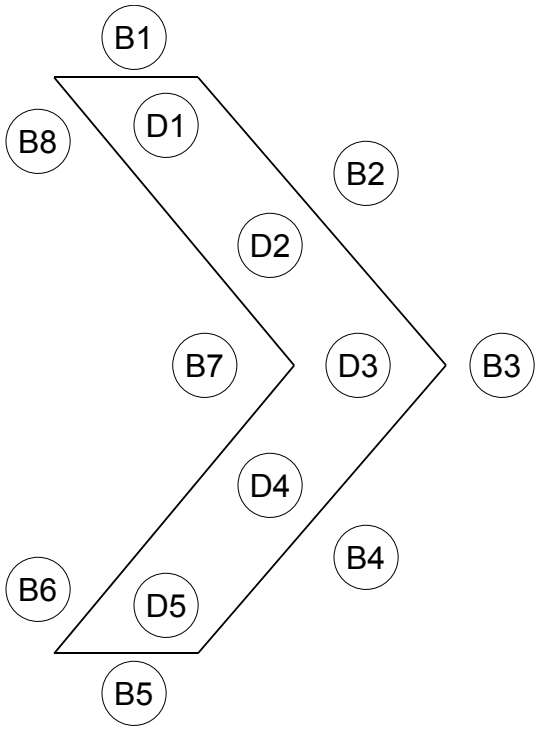

D1 – D5 on directional indicator

B1 – B8 on background

Figure 9 – Luminance measurement points for the chevron, energized state

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7.3.2

The measurement circular area shall be within one-third to one-half the width of the stroke except for the chevron. The measurement area shall have a diameter of no more than 9.5 mm (0.375 in.) for the legend and 1.5 mm (0.06 in.) for the chevron. The distance between the outermost edge of any character or chevron, if provided, and the perimeter of the circular area, shall be greater or equal to 3 mm (0.125 in.). Additional test points may be required at the discretion of the testing agency.

7.3.3

Luminance shall be measured along an axis perpendicular to the face of the sign for circular areas contained within each luminous element of each character and chevron.

7.3.4

The luminance measured at each measurement point shall be recorded, and the mean luminance of the legend shall be calculated in accordance with clause 8.2. See Figures 6-9.

7.4 Background

7.4.1

The luminance of the background of an exit sign shall be measured in units of cd/m^2. Luminance shall be measured for circular areas located at the points shown in Figure 6 for testing in the non-energized state and Figure 8 for testing in the energized state, as appropriate.

7.4.2

The diameter of the circular area shall be greater than or equal to 0.8 mm (.03 in) and less than or equal to 9.5 mm (0.375 in.), and the distance between the outermost edge of any character or chevron, if provided, and the perimeter of the circular area shall be greater than or equal to 3 mm (0.125 in.).

7.4.3

Luminance shall be measured along an axis perpendicular to the face of the sign for circular areas contained within each luminous element of each character and chevron.

7.4.4

The luminance measured at each measurement point shall be recorded, and the mean luminance for the background shall be calculated in accordance with clause 8.3. See Figures 6, 8, and 9.

8 Luminance calculations

8.1 Contrast formula

The luminance contrast shall be calculated using the following formula where the mean legend and chevron luminances are measured and calculated in accordance with clause 7.3, and the mean background luminance is measured and calculated in accordance with clause 7.4:

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$$C = \frac{L_G - L_L}{L_G}$$

Where:

C = contrast ratio

L_G = greater of the mean luminance of the legend (and chevron) or the background, cd/m^2

L_L = lesser of the mean luminance of the legend (and chevron) or the background, cd/m^2

8.2 Mean luminance of the legend

The mean luminance of the legend shall be calculated using the following formula:

$$L_{legend} = \Sigma L_{points} / N_{points}$$

Where:

L_{legend} = mean luminance of the legend, cd/m^2

L_{points} = luminances of the individual measurement points within all of the characters of the legend, cd/m^2

N_{points} = total number of luminance measurement points within the legend

8.3 Mean luminance of the background

The mean luminance of the background shall be calculated using the following formula:

$$L_{background} = \Sigma L_{points} / N_{points}$$

Where:

$L_{background}$ = mean luminance of the background, cd/m^2

L_{points} = luminances of the individual points within all of the characters of the background, cd/m^2

N_{points} = total number of luminance measurement points within the background

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