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ON-PREMISE SIGN STANDARDS

Research Based Approach To:

Sign Lighting

USSCF ON-PREMISE SIGNS / BEST PRACTICES STANDARDS

United States Sign Council Foundation
Best Practice Recommendations & Standards for On-Premise Sign Lighting

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A Research Based Approach To:

Sign Lighting

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Table of Contents

Preface, The Continued Advancement of Scientific Research 1
Listing of USSC On-Premise Sign Illumination Research
and Related Publications 2
OVERVIEW, Seeing and Reading On-Premise Signs During Daytime 3
History of Sign Lighting 4
OVERVIEW, Seeing and Reading Illuminated Roadside
On-Premise Signs - Special Requirements at Night 5
Sign Lighting Regulations and the US Supreme Court
Case Reed v Gilbert 6
Sign Illumination Terminology in these Best Practices Standards..... 7
The Needs of the Driver and Traffic Safety Defined 10
Accurate and Appropriate Measure of Sign Brightness:
Luminance in the Context of a Roadway Environment 11
International Dark-Sky Association 13
Illuminating Engineering Society 13
Photometric Terms and Concepts 13
How Sign Lighting is Regulated Currently 17
The Dilemma of Dimming 20
Do On-Premise Signs Belong in Lighting Zones? 21
Visual / Light Adaptation 23
What is an Outdoor Lighting Code? 24
USSC On-Premise Sign Lighting Best Practices Standards 24
Other Existing EMC Brightness Recommendations 29
How to Get Information on Sign Brightness 31

Figures and Tables

Figures:

Figure 1. Packard Neon Sign 5
Figure 2. Internally Illuminated Signs 7
Figure 3. Externally Illuminated Signs 8
Figure 4. Directly Illuminated Signs 8
Figure 5. Luminance and Illuminance Illustration 12
Figure 6. Wattage and Lumens Comparison 19

Tables:

Table 1. Metric and English Conversion Chart 16
Table 2. IESNA Light Trespass Levels 22
Table 3. Speed Reduction for Externally Illuminated Signs..... 26

Preface: The Continued Advancement of Scientific Research

In 1996, the United States Sign Council (USSC) and its research arm, The United States Sign Council Foundation (USSCF), began research into the legibility and traffic safety implications of roadside on-premise signs. Prior to that time, very little research existed relative to the design and safety characteristics of this type of sign. Traffic engineers, seeking to develop a directional sign system to be used by motorists on local and interstate highways, had promulgated some earlier academic research. However, although useful as a starting point, the data had little relevance to the distinct qualities of private roadside signs. By virtue of their diversity and placement on private property, on-premise signs exist as a totally separate class of motorist-oriented communication, encompassing unique design challenges and traffic safety implications.

Since that time, the USSCF, together with traffic engineers, human factors researchers, and statistical analysts of the Pennsylvania/Larson Transportation Institute of the Pennsylvania State University, has published a series of research studies. The results from this work now provide a distinct and objective scientific basis for understanding the manner in which drivers receive and respond to the information content of the private, roadside sign system. The research and corresponding analyses afford designers and regulators of signs with an insight into the characteristics of effective roadside communication.

All research, guidelines, standards, recommendations and discussion contained in this publication relate to on-premise signs only.

These recommendations and standards combine USSCF research on sign lighting, existing research from other sources on sign lighting and an understanding of the mechanics of zoning and legal requirements for on-premise

signs. This synthesis is intended to create a better understanding of sign lighting issues, resulting in knowledgeable decisions in the future.

A majority of on-premise sign lighting research currently available has been conducted by the USSCF. This endeavor, at its core, has been an effort to promote traffic safety and meet the needs of the driver. Traffic safety is at the heart of USSCF on-premise sign research.

Listing of USSC On-Premise Sign Illumination Research and Related Publications

Seven (7) publications comprise the United States Sign Council Foundation / Pennsylvania Transportation Institute / Larson Transportation Institute and the Visual Communications Research Institute collaborative research work on sign lighting:

1) ENVIRONMENTAL IMPACT OF ON-PREMISE SIGN LIGHTING, With Respect to Potential Light Trespass, Sky Glow, and Glare (2004)
2) RELATIVE VISIBILITY OF INTERNALLY AND EXTERNALLY ILLUMINATED ON-PREMISE SIGNS (2004)
3) INTERNALLY ILLUMINATED SIGN LIGHTING, Effects on Visibility and Traffic Safety (2009)
4) INTERNAL vs. EXTERNAL ON-PREMISE SIGN LIGHTING, Visibility and Safety in the Real World (2009)
5) ON-PREMISE SIGN LIGHTING, Terms, Definitions, Measurement (2010)
6) ON-PREMISE ELECTRONIC MESSAGE CENTER LIGHTING LEVELS: Phase 1 and Phase 2 (2015)
7) STANDARD LUMINANCE LEVELS OF ON-PREMISE SIGNS (2016)

OVERVIEW, Seeing and Reading On-Premise Signs During Daytime

The United States Sign Council *Best Practices Standards for On-Premise Signs* was first published in 2003, and represented a research-based approach to determining size, legibility and height for on-premise signs. Subsequent editions included guidelines for parallel signs (also known as wall signs and/or building-mounted signs) and for sign illumination. *The Standards* have been widely used to design on-premise signs, to obtain approvals for signs, to develop model sign codes, and have been published by other professional organizations.

While *The Standards* were not unique in recognizing that on-premise sign design should be determined based on roadway and traffic conditions (the American Planning Association's *Street Graphics and the Law* initiated this dialogue back in 1988), the USSC Standards were the first to incorporate contemporary sign research specifically devoted to on-premise signs and develop useful equations for determining letter and sign size. For a complete discussion of all of these factors affecting, see the *United States Sign Council Best Practice Standards for On-Premise Signs* (2016).

In summary, the research and best practices standards show that sign visibility, also termed "detection", and sign legibility, also termed "comprehension" – the ability to read and understand a message - are determined through an interplay between roadway conditions, speed of traffic, sign size and sign design. Based upon these factors, a driver is able to make a decision and/or execute a driving maneuver after receiving the communication obtained from the on-premise sign.

The factors that impact the ability of a driver to see and read a sign and execute a corresponding driving maneuver include concepts such as: complexity of driving environment, sign orientation, sign lateral offset, message scan timeframe, time required for driving maneuver, viewer reaction time, viewer

reaction distance and sign legibility derived from the research-based USSC Legibility Index.

All of the elements that are involved in on-premise sign visibility and legibility during the day apply equally to signs at night, and will not be re-stated here, except to note that nighttime conditions present additional factors that impact sign detection and legibility, which sign illumination is designed to address.

History of Sign Lighting

Illuminated signs are a historic feature of the American landscape. Signs have been illuminated by gas lighting as far back as 1840 (at the legendary P.T. Barnum's museum). In 1891, the first electric sign spectacular was erected in New York City, using incandescent bulbs. In fact, the advent of the twentieth century brought widespread use of electricity, which gave signs an improved lighting source, and by 1900, electrical sign manufacturers were growing in the United States. As a bonus, electricity represented a safer and cheaper source of illumination vs candles, kerosene or gas.

Certain inert gases continued to be used, however, for neon lighting (gas enclosed glass tubes energized using electricity), which was first demonstrated in December 1910 by Georges Claude at the Paris Motor Show. In 1923, neon signs were introduced to the United States when Claude and his French company Claude Neon sold two neon Packard signs to a car dealership in Los Angeles.

Although the technology for both fluorescent lamps and acrylic plastics existed as far back as the early 20th century, use of both materials for illuminated signs became widespread on a consistent basis after World War II.

Figure 1. Packard Neon Sign

In the 21st century, signs can be manufactured using a wide variety of materials and lighting sources, and illuminated signs can take advantage of more than one hundred years of technological development. Typical sign lighting sources today include: incandescent bulbs, fluorescent lamps, mercury vapor lamps, LEDs (light emitting diodes), and neon.

OVERVIEW, Seeing and Reading Illuminated Roadside On-Premise Signs - Special Requirements at Night

On-premise signs are most visible and legible during the day. For the purposes of traffic safety and the needs of the driver, sign illumination practices at night attempt to get sign visibility and legibility as close as possible to daytime benchmarks. The functions of on-premise signs are no less critical after dark as they are during daylight hours, and their functional value may be even more critical to the safety and cognitive implications for older drivers, whose visual acuity has been shown to deteriorate markedly at night.

On-premise sign lighting guidelines also reflect the informational transfer and communication aspects that are unique to the on-premise sign medium, as these

types of signs provide a primary means of roadside communication and situational awareness for drivers, raising potential legal and constitutional issues. It is this place-based orientation that gives on-premise signs their unique character, but which also acts to limit their communicative ability to a relativity short span of time during which they can be seen by any given driver.

Central to these guideline sign lighting recommendations and standards is the concept that well-designed sign lighting can aid a driver in rapid and accurate recognition and understanding of a sign's message. Key factors that are recognized in the lighting field to affect the visibility of objects in general include size, luminance (brightness), contrast, and viewing time; each of which also applies to a driver's ability to read an on-premise illuminated sign at night. A further complication is that, in addition to sign reading, the driver is simultaneously conducting other driving-related tasks.

Sign Lighting Regulations and the US Supreme Court Case *Reed v Gilbert*

Any sign regulation, including sign lighting regulation, falls within the purview of the recent US Supreme Court decision in *Reed v. Town of Gilbert, 135 S. Ct. 2218 (2015).* The ultimate impact of the Reed decision is still to be determined, but the same general principles articulated in the Reed decision applied to sign regulations before Reed, and they required that sign regulations be content-neutral, and not content-based.

Sign regulation that falls within the category of content-neutral "time, place and manner regulations" of on-premise signs have always been a valid exercise of local regulatory authority over the speech being displayed on on-premise signs.

The Reed Court emphasized that municipalities continue to be able to control signage via content-neutral time, place and manner regulations. Because of this,

greater emphasis will be placed on the dimensional and physical characteristics of signs, and this will create even greater attention to how signs are designed and installed. A science-based and research-based approach to sign regulation will therefore become even more critical, post-Reed, and the *USSC Sign Lighting Best Practices Standards* can be a valuable tool in that regard.

Sign Illumination Terminology in these Best Practices Standards

On-premise signs can be illuminated at night using a variety of lighting techniques. There are three principal methods for lighting an on-premise sign at night – internal illumination, external illumination and direct illumination – and these types of sign lighting have been studied over the course of the research.

Figure 2. Internally Illuminated Signs

Internal illumination: An internally illuminated on-premise sign has its lighting element or lighting source contained inside a sign cabinet, letter module, or sign body. Typical lighting elements used for internal illumination include fluorescent lighting, neon tubing, and light-emitting diodes (LEDs). An internally illuminated sign requires that some part of the sign or sign face be translucent, for instance a letter face or a sign face, so that light can transmit through the translucent material and be visible at night when the sign lighting elements are

energized inside. With internal illumination, the viewer never sees the lighting element directly.

Figure 3. Externally Illuminated Signs

External illumination: An externally illuminated on-premise sign has its lighting element or source installed outside the sign, directed toward the sign face, letters, or sign message. Typical external lighting sources include fluorescent lighting, spotlights, floodlights, and gooseneck lamps. With external illumination, the sign is illuminated via reflected light.

Figure 4. Directly Illuminated Signs

Direct illumination: A third method of sign lighting may be slightly less common, but has the longest history. With direct sign illumination, nothing stands between the eye of the viewer of the sign and the lighting element. There is no

translucent lens or cover or baffle or light being indirectly reflected upon a surface. Direct lighting components include exposed neon tubing on signs and letters, incandescent and LED-based exposed lamp bulbs on theater, event signage, and other types of decorative applications, and lighting sources used in EMC signs. Currently, the vast majority of EMC signs use a LED lighting source.

Electronic or digital signs: For the purposes of these guideline standards, computer-controlled electronic signs will be termed EMCs, standing for Electronic Message Centers. In the literature, these types of signs are also referred to as digital signs, electronic signs, and changeable message sign (CMS). These guideline standards do not refer to or apply to electronic billboards or digital billboards. EMC signs use a direct illumination source.

Static signs: signs with a permanent message; signs with a message that cannot be or is not intended to be changed frequently; signs where a message cannot be changed through electronic communication; these types of signs represent the vast majority of signs installed in the United States. A static on-premise sign has a message that is not changed, or is not changed very frequently, or without a lot of effort.

EMC signs: signs that display messages that can be controlled and changed remotely; signs that can display dynamic messages; signs whose messages change periodically; EMC signs use direct illumination; the LED light sources compose the pixels that make up a grid that can display lettering or graphics or both and are controlled via computer.

Many illuminated signs are manufactured electrical products (meaning the sign that is fabricated complete in a place of manufacture, including lighting, and then installed in the field) and are regulated by local and national standards for electrical and fire safety. These standards include the National Electric Code

(NEC), as well as listing and testing agencies such as Underwriters Laboratories (UL). There are few if any rules regarding the installation of lighting for externally illuminated on-premise signs, the appropriate placement of external lighting fixtures, and the type of lighting required for any particular sign application.

The Needs of the Driver and Traffic Safety Defined

The on-premise sign regulation process involves many stakeholders: typically local government, sign owners, local residents, and professionals serving those stakeholders. The most important stakeholder by far is unmentioned - the driver - the individual who actually uses the sign information on the sign and has critical informational needs.

Serving the needs of the driver by insuring that signs are appropriately designed, positioned and sized in turn serves traffic safety, not only in accident prevention, but in minimizing inappropriate and/or avoidable driving behaviors. These behaviors include: slowing down to read a sign, stopping abruptly when a sign is recognized, passing a sign and then executing a u-turn to come back to the desired destination, changing lanes abruptly to get into position to turn off the roadway, failing to indicate a change of lanes with adequate time and distance for those behind, failing to indicate a turn off of a roadway within an adequate time or distance.

In regard to sign lighting, research indicates that incorrect sign lighting specifications can have a negative consequence for drivers. This includes scenarios where sign lighting is too dim and drivers have a harder time reading the messages, thereby requiring more time to read the sign and more distance to be ready to maneuver, as well as scenarios where permitted signs are over-bright, and drivers have a harder time focusing in on sign messages due to discomfort glare.

Current focus in most sign lighting regulations is on EMC signs. However, a sign code with lighting regulations, or a stand-alone outdoor lighting code that includes on-premise signs, generally encompasses all on-premise signs, not just EMC signs, including static on-premise signs of all types. Therefore, a substantial effort has been made to research lighting levels for all types of on-premise signs at night.

Key Fact: On-premise signs need to be visible and legible for drivers from a distance, which, depending on posted speeds, can range from 250'-0" to 800'-0", and beyond.

Accurate and Appropriate Measure of Sign Brightness: Luminance in the Context of a Roadway Environment

The USSC standard for the measurement of on-premise sign illumination is "luminance". Adequate luminance values for on-premise signs at night have been found to provide proper legibility and reading sight distances for drivers without any significant impact on environmental light trespass or sky glow.

There are two accepted ways to consider and measure the light produced by an object or sign. The first is to measure the "brightness" of the object or sign at the face of the object or sign, or its "luminance." Luminance measures light output at its source, is a constant, and does not vary with ambient light conditions. Luminance is an objective standard of measure as applied to signs, and allows comparative research on sign brightness and driver performance. Internally illuminated signs, externally illuminated signs and EMC signs all can be measured for luminance.

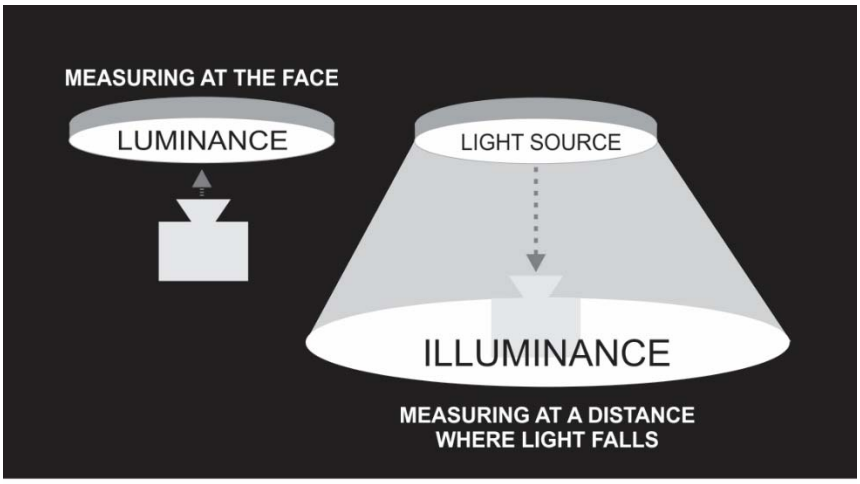

Figure 5. Luminance and Illuminance Illustration

There is a second metric that can be applied to objects or signs, termed "illuminance", which refers to measuring the projection of light from an object or sign into surrounding space, such as light cast by a sign onto a property line or ground surface. Illuminance measurements are extremely distance-dependent, and this reduction in light based upon distance is measurable at any point from the sign at a rate equal to the square of the distance from the sign. Illuminance is a subjective standard of measure as applied to signs, meaning that it can vary greatly, and can be affected by a variety of factors, some not even related to the sign itself. Illuminance has only an indirect relevance to on-premise signs. Since on-premise signs are not designed to cast light on other objects or spaces, their illuminance only becomes relevant in terms of its possible relationship to the environmental concept called "light trespass".

Key Fact: an illuminance measurement does not measure sign brightness.

Key Fact: **Luminance: asks "how bright is that light?"**
Illuminance: asks "how much light is reaching point X?"

International Dark-Sky Association

The International Dark-Sky Association (IDA) was founded in 1988 by a group of scientists and astronomers based on preserving the night sky, and is an Arizona-based non-profit organization. IDA first started as an idea to help astronomers focus their telescopes onto distant objects in the sky, and has now become a large membership-based organization with worldwide participation.

The IDA's initial focus was on improving outdoor lighting so that unnecessary light would not affect astronomical operations. IDA wanted to help create functional outdoor illumination that would have less impact on the night sky. Today, IDA's agenda is advanced in two ways: (1) advocating limits on overall exterior nighttime lighting; (2) promotion of an energy conservation agenda.

Illuminating Engineering Society

The Illuminating Engineering Society (IES, formerly known as IESNA the Illuminating Engineering Society of North America) is a non-profit organization founded in 1906, and is the world's preeminent association of lighting professionals. The Society has issued hundreds of publications on lighting and lighting practices including standards, design guides, technical memoranda, and lighting energy materials.

Photometric Terms and Concepts

A key to unlocking the mysteries of sign lighting terms and measurements, and therefore a key to good lighting guidelines, is an understanding that two systems of lighting terminology appear in the United States: English terminology and SI (metric) terminology. This dual system of terms has some codes using metric measurements, while others using English measurements, and, in some cases,

ill-conceived codes using terminology from both systems. It is critical to be aware of the two systems and their terminology and measurement conversions, because the difference between them can be as much as a factor of ten.

Key Fact: there are (2) systems of terminology.

Key Fact: the USSC Guideline Best Practices Standards use SI (metric) terminology. Reasons: there is existing data and research that is more easily compared and understood using the international terminology; many lighting terms currently used, such as "lumens" and "nits", have their derivation from the International System of Units (SI) terminology.

Basic building blocks in each system are:

Luminance - A unit expressing the brightness of the source

SI (Metric) Term	English Term
Basic unit is a "Candela"	Basic unit is a "Candle"
Candelas per meter squared	Candles per foot squared
(Also known as "nits")	(Also known as Foot-Lambert)
cd/m^2	cd/ft^2

Candela per square meter (cd/m^2) – The SI (metric) unit used to describe the luminance of a light source or of an illuminated surface.

Foot Lambert (fl or cd/ft^2) – An English unit of measurement of the amount of light emitted by or reflecting off a surface (luminance) equivalent to 3.4262591 candelas per square meter.

Illuminance – a unit expressing amount of light falling on a place or object; amount of light at a distance;

SI (Metric) Term	English Term
Lux One lux is equal to one lumen per square meter.	Foot-Candles One foot candle is equal to one lumen per square foot.

Lux (lx) – The SI (metric) unit for illuminance, or how much light falls on a surface. One lux is equal to one lumen per square meter. One lux equals 0.093 foot candles

Foot Candle (fc) – An English unit of measurement of the amount of light hitting a surface (illuminance). One foot candle is equal to one lumen per square foot. One foot-candle as about ten lux (10.76). Therefore, it is commonplace to simply state 1 fc = 10 lux. A foot-candle is equivalent to one lumen per square foot (where a lumen is a measure of the luminous flux, or quantity of light).

Key Fact: don't mix terminology; metric values are higher vs English values.

	English	Conversion to SI (metric)	SI (metric)
Luminance	foot lambert (fL or ft-L)	x 3.43	cd/m^2
Illuminance	foot candle (fc)	x 10	lux (lx)
	SI (metric)	**Conversion to English**	**English**
Luminance	cd/m^2	X 0.29	fL or ft-L
Illuminance	lux (lx)	x 0.1	fc

Table 1. Metric and English Conversion Chart

Key Fact: an illuminance reading of a sign can be converted to a luminance value using a simple formula. You need to know the illuminance reading of the sign, the distance from the sign where the illuminance reading was taken, and the size of the sign.

The formula for average sign luminance in SI (metric) terminology: candelas per meter squared cd/m2 (also know as "nits") is approximately:

Luminance = E x D / [Area of sign]

E is the sign illuminance in lux SI (metric)
D is the distance from the sign where the illuminance was measured in meters squared (m^2) SI (metric)
Area of the sign is in meters squared (m^2) SI (metric)

Example:

5 lux reading x 441 m^2 (21 meters squared or 70 FT) / 3.71 area in meters squared (40 SF) area
Yields a sign luminance at night of 594.34 nits or cd/m^2

How Sign Lighting is Regulated Currently

There are four distinct approaches to on-premise sign illumination regulation.

1. No sign lighting regulation
2. Brightness standard
3. Light trespass standard / Nuisance standard
4. Energy conservation standard

1. No sign lighting regulation is quite commonplace. Research indicates that on-premise signs don't consume a great deal of power, have brightness levels that have not been associated with light trespass, and do not contribute to sky glow in any agreed-upon measurable way. Other factors involved in omitting signs from outdoor lighting regulation include: regulation could alter the distance at which signs are readable and legible and potentially compromise safety; signs display constitutionally-protected communications, whereas outdoor lighting fixtures do not.

2. The original *USSC Best Practices Standards for On-Premise Signs* recognized an objective "sign brightness" model for sign illumination. The standard of measurement is sign "luminance", which can be tested and compared across all types of signs and methods of sign lighting. This model is used primarily to address the needs of the motorist and traffic safety, and dovetails with on-going research on on-premise signs.

3. Regulations that are based on a light trespass standard / nuisance standard are concerned with measuring the illuminance of a sign and are focused on issues of light trespass; derived from the common law, light trespass is a nuisance standard for regulating sign lighting.

These types of regulations focus on gauging a sign's brightness relative to ambient light, or gauging a sign's brightness at a property line or certain distance from the sign, or trying to limit unwanted light or objectionable light.

The Illuminating Engineering Society (IESNA or IES) describes light trespass as "light that strays from the intended purpose and becomes an annoyance, a nuisance, or a detriment to visual performance." It is light that shines where it is not wanted. Light trespass can result in glare if it is shining in someone's eyes, or it can simply annoyingly light up an area it is not supposed to illuminated.

Measuring illuminance, or light trespass, is dependent on the distance from the sign to the measurement location (adjacent property, a property line etc). Research has shown that internally illuminated signs have low initial light levels that fall off rapidly with distance, and these types of signs have virtually no significant light trespass. There may be potential problems with badly aimed lighting of externally illuminated signs, in particular when spot or flood lights spill over the edges of the sign or are so poorly aimed that they miss the sign altogether, and with over-bright EMC signs. Nonetheless, sign codes may address the issue of light trespass by requiring that the illuminance of signs at the property lines be restricted to a specific level.

4. Sign lighting regulations that focus on "lumens" or "watts" in their regulatory language are addressing issues of light trespass and energy conservation. Regulations focused on lumens or watts are in practice regulating the characteristics of the lighting luminaires or lighting sources or lighting fixtures and how much light they could project to a certain distance, not the actual brightness of the completed sign at the sign itself, or they are regulating light trespass, or how many lumens per square foot (English) or per square meter (metric) fall at a designated distance.

Figure 6. Wattage and Lumens Comparison

In regard to lumens, this term is used in a formula to indicate or measure the amount of light that may fall in any particular place at a set distance; the term "lumens" is used in both the SI (metric) and English system terminology;

Key Fact: whether one is referring to "lumens per square foot" or foot-candles (fc) or "lumens per square meter" or lux (lx), this is a distance-dependent calculation; it will change with distance from a sign.

Watts measures the amount of energy used by that light source. A "watt", named after Scottish engineer James Watt (1736–1819), is derived from the International System of Units (SI - metric) and can be used to quantify the rate of energy transfer - the rate at which energy is utilized. Sign lighting regulations that refer to watts are interested in energy conservation for the most part.

There is a trap when lumens or watts are applied to illuminated on-premise signs if the objective is to determine or confirm the actual brightness of the sign. From the perspective of the driver, the brightness of the final completed sign itself is

most important, not the luminous rating (lumens) or energy consumption (watts) of the lighting elements inside the sign. These can be two very different things.

Unfortunately there is no current research that correlates and/or aligns lumens per square meter or per square foot and/or watts and sign legibility at night, so there is no benchmark available to begin an objective evaluation. A lack of reliable guidance whether any particular level of lumens or watts is a good limit underscores this observation.

Key Fact: the ability to see (and read a sign) and light trespass are completely unrelated.

The Dilemma of Dimming

If on-premise signs are dimmed, a scientifically-verified standard would be needed to insure that the adjusted lighting levels still meet the needs of drivers. Otherwise, compromised traffic safety may result. At present, this research is not available.

For example, there is no effort to dim the runway lights at airports in order to conserve energy and prevent light trespass. These runway lights are a form of "outdoor lighting" and are directed toward the sky, thereby potentially contributing to light pollution and sky glow. Because runway lights at airports serve a safety function, most would agree that it would be ill-advised and against public safety to dim runway lights, thereby making the runway lights harder to see for pilots. These same principles hold true for illuminated on-premise signs. Illuminated on-premise signs perform a vital traffic safety function and are used by drivers as part of an overall wayfinding system that allows them to navigate from Point A to Point B at night. An arbitrary diminution of on-premise sign lighting below appropriate levels for sign visibility and legibility could have a negative impact on

traffic safety and the ability of drivers to see and comprehend sign messages, based upon current research. This does not mean that brighter signs are always better. It means rather that there are tested lighting levels that facilitate sign detection and legibility, and those levels can be recognized and permitted from a regulatory standpoint.

Do On-Premise Signs Belong in Lighting Zones?

The concept of “Lighting Zones” is not a recommended guideline standard for establishing on-premise sign lighting levels at night. The concept is included here by way of discussion and explanation.

The concept of Lighting Zones was developed due to concern over light pollution from outdoor lighting. At times light pollution and light trespass are used interchangeably in the literature, though they each have a slightly different focus. Light pollution encompasses light that radiates in all directions, including upward. Light trespass refers to light on a more horizontal plane, particularly at a property line.

Lighting levels for four “environmental zones” were first identified by the International Commission on Illumination (CIE) in 1997 in response to complaints from the international astronomical community (professional and amateur) about the reduction of night sky visibility due to light pollution in the form of sky glow. Zones have gained increasing acceptance by lighting professionals and provide a conceptual framework to consider lighting levels in varying outdoor environments. The concept was later modified by the IDA and IES in their 2011 Model Lighting Ordinance (MLO) to include five recommended lighting zones. The original four (4) CIE lighting zones are as follows:

• Environmental Lighting Zone 1: Areas with intrinsically dark landscapes: National Parks, or areas of outstanding natural beauty (where roads are usually unlit)

• Environmental Lighting Zone 2: Areas of low brightness: outer urban and rural residential areas (where roads are intermittently lit to residential standards)

• Environmental Lighting Zone 3: Areas of medium brightness: generally urban residential areas (where roads are lit to traffic route standards)

• Environmental Lighting Zone 4: Areas of high district brightness: generally urban areas having mixed residential and commercial land use with high night-time activity

IESNA (2000c) recommended light trespass illuminance levels.

Environmental Zone	Illuminance (lx)
E1	1.0
E2	3.0
E3	8.0
E4	15.0

Table 2. IESNA Light Trespass Levels

Zone 2 would have a lower permitted outdoor lighting brightness as compared to Zone 4, for instance. Areas with lesser ambient light would have lower lighting limits while areas with higher ambient light would have higher permitted lighting values. While this type of regulation provides insight into how bright a light source should be to prevent annoyance and discomfort, it does not address the very important issue of the effectiveness of the lighting.

For example, an “Outdoor Lighting Ordinance” could focus on the amount of light that may fall on an adjacent property line (horizontal illuminance) or the sky (vertical illuminance). This type of ordinance would set a maximum illuminance factor, in Lux or Foot-candles, at a specific distance from the light.

Key Fact: Lighting zones were designed with luminaires in mind, and were never intended to apply to on-premise signs.

Key Fact: The 2011 IDA-IES Model Lighting Ordinance includes Lighting Zones and does not regulate on-premise signs (exempts signs from the regulatory provisions of the Model code). It suggests that signs should be governed by a local sign lighting ordinance.

Visual / Light Adaptation

Researchers advance four types of light adaptation. The human eye can dark adapt, going from bright to dark environment, or light adapt, going from dark to light. Within each of these adaptations there are two reaction time frames: a slow adaptation and a transient phase adaptation. By definition, a slow adaption is a gradual process that can take 30-45 minutes (going from a dark movie theater to bright sunlight), and both light and dark transient adaptation can take place in approximately a second or two. Slow adaption does not have relevance to the discussion in these guidelines on sign lighting.

Dark transient adaptation is a complex phenomenon involving human physiology. As it relates to the driving task, drivers at night adapt to a middle range of light level, not bright light, not complete darkness, but something of a hybrid in between. A driver experiences changing ambient light levels when driving along a roadway, and there is a continuous flow of light sources entering the driver’s central and peripheral vision - including but not limited to traffic signals, signs,

headlights from other cars, taillights, outdoor lighting on properties adjacent to the roadway, street lights – and this causes the level of adaptation to constantly shift up and down in a transient manner. In regard to sign lighting, because drivers at night are generally adapted to light levels lower than those found in the daytime, signs should be illuminated to maximize legibility and not create discomfort glare.

Key Fact: based on USSC Legibility guidelines, illuminated on-premise signs at night need to be visible and legible for up to 6 to 10 seconds, or from 250'-0" to 800'-0" away from the sign, depending on posted speeds and roadway conditions.

Key Fact: Whether you use a Luminance meter or an Illuminance meter for photometric measurements, the target determinations, using formulae, should always be to establish a sign's luminance.

What is an Outdoor Lighting Code?

An outdoor lighting code is a legal document that establishes permitted and prohibited lighting practices, with an emphasis on limiting obtrusive aspects of lighting more than an emphasis on good lighting practices per se. Most lighting codes are concerned primarily with limiting the wide-reaching effects of stray light that causes glare, light trespass, sky glow, and energy conservation.

USSC On-Premise Sign Lighting Best Practices Standards

(A) Where on-premise sign lighting is regulated, the USSC has established sign illumination guideline standards for on-premise signs at night based on the results of completed contemporary research. The USSC guideline standards are based on the luminance of a sign. As discussed above, luminance is the measurement of the brightness of a sign at its face. Testing has provided

luminance levels for sign detection and legibility using different color combinations.

The USSC Sign Illumination Guideline Standard for maximum sign brightness at night:

Illuminated sign brightness shall not exceed the maximum luminance level of seven hundred (700) cd/m² or Nits at least one-half hour before apparent sunset, as determined by the National Oceanic and Atmospheric Administration (NOAA), US Department of Commerce, for the specific geographic location and date. It is also recommended that all illuminated signs comply with this maximum luminance level throughout the night, if the sign is energized, until apparent sunrise, as determined by the NOAA, at which time the sign may resume luminance levels appropriate for daylight conditions, when required or appropriate.

This guideline standard for sign brightness does not dictate that all signs should have a maximum brightness level of 700 nits; rather, it sets the outer-most brightness level for signs, beyond which on-premise sign brightness should not extend.

Research has shown that the vast majority of on-premise signs, including both static signs and EMC signs, using different color combinations and designs, will have luminance values far below the maximum standard for brightness at night. The 700 nits maximum luminance will generally be the result of a color combination involving white and black for both static and EMC signs. Many color combinations will have luminance levels far below the 700 nits maximum due to the inherent qualities of each color, sign materials and sign construction.

Formalizing a prohibition on certain colors and color combinations is not recommended from an enforcement, legal and constitutional perspective.

Research has not shown that any particular color scheme has a negative impact on a driver's ability to see and read a sign, assuming proper contrast and design.

(B) Illuminance (light trespass): Illuminance measurements for any particular sign will vary based on distance from the sign, and drivers are generally traveling continuously along a roadway as they view the sign at changing distances. On-premise sign viewing distances for sign legibility are different for each sign, based on a multitude of factors. Use of an illuminance standard for on-premise sign brightness does not offer a uniform and easy-to-apply guideline, and is almost impossible to test for from a detection and legibility standpoint.

(C) Do different methods of sign illumination impact sign efficacy?

Yes, internally illuminated signs outperform externally illuminated signs.
Where roadways have posted speeds of 25 MPH or greater, internal illumination should be permitted, as it provides longer viewing times and distances for drivers vs external illumination, with less impact on the environment and more energy efficiency vs externally illuminated signs.

The reduction in speed of a driver approaching an externally illuminated sign needed to achieve the Viewer Reaction Time and Distance of an internally illuminated sign

Internally Illuminated	Externally Illuminated
35 MPH	20 MPH
45 MPH	25 MPH
55 MPH	30 MPH

Table 3. Speed Reduction for Externally Illuminated Signs

Externally illuminated static signs display relatively low brightness (luminance) levels, which is to be expected given that the visible sign illumination is delivered via reflected light. Externally illuminated signs can also create more light pollution and sky glow consequences via directed upward light, spill light, and back light as compared to internally illuminated signs.

(D) Are there lighting levels where a sign can be too dim to be functional for the motorist or too bright, with no corresponding improvement in visibility?

By their very nature, different color combinations have different brightness values. Signs, including EMC signs, have tested best over a range of luminance for sign visibility and/or legibility. Dimming signs below that threshold, or above, could have an impact on drivers, particularly with certain colors and color combinations, and for certain age groups.

Some research has shown that sign legibility increases as luminance increases, up to a point where performance levels off. With further increases, the legibility is not improved; it may reach a point where visual performance is actually reduced due to excessive brightness. The same holds true for lower lighting levels. The relatively sharp fall-off in performance at low and high luminance levels coupled with a range of luminance at which good performance is sustained is referred to as “plateau and escarpment”. The plateau occurs when luminance is sufficient to achieve a relatively consistent and high level of visual performance, and the escarpment representing the region where performance drops off fairly sharply as luminance goes above or below a particular level.

(E) Should there be guideline maximum brightness for static signs and separate guideline maximum brightness for EMC signs?

No, at night, they should be one and the same. Whether one is looking at research on static sign brightness at night or EMC sign brightness at night from the standpoint of visibility and legibility, the results to date have fallen within the same general range, with a maximum recommended nighttime brightness of 700 candelas per square meter, or 700 nits, for all types of signs. This value is not the average brightness, but the maximum.

(F) Additional guidelines and considerations related to EMC signs.

EMC signs, today typically using LEDs as a light source, can be dimmed and can adjust their lighting output, depending on time of day or night and outside light conditions. In practice, static signs are not dimmed, or adjusted for general lighting conditions. Lighting adjustments for EMC signs are critical for EMC sign visibility and legibility, because EMC signs must be energized to be visible during the day, and they therefore increase their brightness during the day. However, at night, they must be dimmed to only 2% to 8% of daytime EMC brightness, so that the EMC signs are not over-bright for drivers after dark.

EMC sign manufacturers rate the brightness of their EMC signs and regulate the brightness of their EMC signs based on a brightness or luminance standard. EMC signs using certain color combinations may approach 10,000 nits during the day, depending on daytime conditions, and reduce to 300 nits to 700 nits at night, again depending on the color combinations displayed.

This EMC lighting adjustment is accomplished using several methods:
1. Photo cell control hosted at the EMC sign senses the general outdoor light level and sends the information to the computer controlling the sign. The computer and related software make the necessary adjustments to the EMC sign.

2. Software itself can automatically tell an EMC sign to adjust lighting levels. Built into the software controlling the EMC sign can be information on sign location, calendar, length of day and night, and so forth.
3. Using the software, the EMC brightness can be adjusted manually/directly.

A sample regulation might read, in addition to the 700 nits maximum luminance : “Electronic message centers shall come equipped with dimming technology that automatically adjusts the display's brightness based on light conditions”.

If questions arise regarding EMC brightness level in the field, they can be easily addressed. At night, access the EMC software, display a black background with white text image on the sign, and confirm the existing brightness level inside the EMC software; if it is over 700 nits, adjust the brightness level downward until below 700 nits and/or to a similar approximate level that is acceptable. Set that as the maximum brightness inside the EMC software.

EMC enforcement issues include having EMC regulations that are clear and easy to understand and apply, thereby facilitating uniform enforcement.

Finally, communities historically have had concerns about on-premise sign lighting on properties that are adjacent to residential areas, particularly EMC signs. The *USSC On- Premise Sign Lighting Best Practices Standards* provide a baseline for setting brightness levels for all on-premise signs; adjustments for local circumstances, including residential areas, may be made by individual local jurisdictions accordingly.

Other Existing EMC Brightness Recommendations

In 2009, the International Sign Association (ISA) published an “Electronic Message Display Brightness Guide” that contained recommendations on EMC

brightness at night based in a light trespass standard (an illuminance standard). This guide was updated and republished in 2016. The recommendations were based on a report provided by the late Dr. Ian Lewin, a respected lighting expert and past chair of the IES. The report calls for setting maximum EMC brightness by referring to lighting zones and gauging ambient light. The Guide states:

*"*Dr. Lewin recommended the development of brightness criteria based on the Illuminating Engineering Society's (IES) well-established standards pertaining to light trespass, IES Publication TM-11-00. The theory of light trespass is based on the concept of determining the amount of light that can spill over (or "trespass") into an adjacent area without being offensive."

The ISA Guide stated: "it is recommended that EMCs not exceed 0.3 footcandles over ambient lighting conditions when measured at the recommended distance, based on the EMC size". A chart with (34) different sign sizes was provided, along with the corresponding distance to measure each sign size from (since light trespass/illuminance is distance-dependent). Note: .3 footcandles over ambient lighting conditions = 3 lux over ambient lighting condition in SI (metric) terminology.

Using these recommendations may be an efficient and shorthand way of gauging the general brightness of an EMC at night. However, using a light trespass approach to determine maximum EMC brightness creates the following concerns.

One, the recommendations did not make an inquiry as to whether this ambient light standard was appropriate or effective for drivers. The issue of "effectiveness" was not fully explored to take into account the driving task and the distance at which EMC signs need to be visible and legible.

Two, since the resulting maximum EMC lighting levels may be too dim for drivers in certain roadway environments, the potentially conservative recommendations for EMC brightness based on ambient light may create many instances of non-compliance.

Key Fact: one can use the ISA light trespass procedures and calculate the true brightness (luminance) of an EMC sign if you know the EMC sign area, the distance that the reading was taken from, and the illuminance reading itself. This will allow a comparison in the EMC brightness yielded by the light trespass procedures and the driver-oriented recommendations contained in these USSC Guidelines.

Key Fact: If USSCF On-Premise Sign Lighting Best Practices Standards and maximum sign brightness value of 700 nits were reflected in the ISA recommendations, it is likely that the factor above ambient light conditions in the formula would range from .3 fc to .7 fc (3 lux to 7 lux) above ambient, not a flat .3 fc / 3 lx.

How to Get Information on Sign Brightness

Research conducted for the USSCF has examined this issue closely, resulting in several recommendations.

1. Average static sign and EMC sign luminance can be obtained relatively easily when signs are still in the place of manufacture by using both an illuminance meter technique and the formula stated above under Photometric Terms and Concepts, or a luminance meter, sometimes referred to as a “nit gun”.

2. Average static sign and EMC sign luminance can be obtained in the field using a spot luminance meter; however, because of non-uniform lighting of signs (which is often not visible to the eye), these field measurements will be less accurate than using the technique under #1 above.

3. Average static sign and EMC sign luminance can be obtained in the field using an illuminance meter via the formula stated above under Photometric Terms and Concepts if one knows the illuminance value, the measurement distance and sign size or sign dimensions. The illuminance technique is not always amenable to field data collection because of the mounting height of certain signs and the existence of light sources other than the sign.

4. EMC sign luminance can be obtained through reference to the EMC sign controller hardware and software, and can be controlled by same.

5. Average static sign luminance levels can be obtained, for the vast majority of internally illuminated sign color combinations and sign styles, using Standardized Sign Lighting tables available from the USSC.

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