



DEPARTMENT OF COMMUNITY DEVELOPMENT SERVICES

Planning Division

m e m o r a n d u m

TO: The Urbana Plan Commission

FROM: Robert Myers, AICP, Planning Manager

DATE: July 2, 2009

SUBJECT: Plan Case No. 2110-T-09: Request by the Zoning Administrator to amend Section IX-4.C of the Urbana Zoning Ordinance regarding sign illumination

Introduction

This plan case is a request to amend Section IX-4.C of the Urbana Zoning Ordinance by adopting a maximum light level for electronic signs. Urbana's sign regulations currently allow signs with electronic display but does not provide maximum brightness standards.

On May 7, 2009, the Plan Commission recommended in favor, and the City Council on June 1, 2009 approved, a comprehensive amendment to the City's sign regulations. An industry standard for electronic sign illumination was not issued until after that revised text amendment had started. Questions about sign illuminations were raised at both the Plan Commission and City Council, and City staff requested time to evaluate the new standard. This memo provides staff's findings and a recommendation for an amendment to the Sign Regulations.

Background

The Outdoor Advertising Association of America (OAAA) commissioned Dr. Ian Lewin, a principal at Lighting Sciences, Inc., Scottsdale, AZ, to recommend criteria for brightness levels on digital signs and billboards. Two important design goals of the study were to minimize the risk of glare and unreasonable driver distraction. Dr. Lewin's April 2009 report (copy attached, and hereinafter cited as "The Lewin Report") recommends criteria based on lighting standards established by the Illuminating Engineering Society of North America (IESNA). The criteria are based on established scientific methodology and established industry standards from the Illuminating Engineering Society of North America (IESNA) publication *Light Trespass: Research Results, and Recommendations (TM-11-00)*. The light trespass theory has become an accepted standard in the lighting industry and was used as the basis for the City of Urbana's recent text amendment to the Zoning Ordinance regarding lighting levels.

The Lewin Report recommends regulatory criteria to limit a sign's lighting level increase to no more than 0.3 foot candles over ambient levels, as measured using a foot candle meter at a pre-set distance. For electronic signs less than 100 square feet in area, the recommended distance for electronic signs is 100 feet.

Following its review, the OAAA now officially endorses The Lewin Report recommendations as an industry-wide standard. The OAAA offers two key elements of sign illumination limits:

- *Require that electronic signs come equipped with a photo cell or other automatic dimming technology based on ambient light levels.* Light output for electronic signs should adjust to account for night/day and cloudy/sunny. In dark conditions, an electronic sign may be legible when emitting only 4% of its maximum possible output, but daytime conditions can require closer to full output.
- *Require a maximum brightness level above ambient light levels.* A maximum of 0.3 footcandles above ambient light level is recommended. Using footcandles as the measurement standard has practical benefits. Footcandle (or Lux) meters are relatively inexpensive and easy to use. Measurement in footcandles also has the advantage of measuring the level of light actually arriving at the meter. In contrast, a Candela Meter (or NITS gun) is not only much more costly (\$3,000 per unit) but also measures light *output* (luminance per square meter) and does not account for ambient light. The OAAA does not recommend using NITS as a measurement standard.

City staff has contacted Daktronics, a company recognized worldwide as a leading designer and manufacturer of electronic signs using light emitting diode (LED) technology. Responding to a question about their view of municipalities regulating electronic sign brightness, a company spokesperson responded that municipal regulation is, "not only needed but paramount." The spokesperson explained that improper (overly bright) operation of electronic signs not only shortens the sign's life span but also reflects negatively on the entire industry.

Pertinent City Policies

2005 Comprehensive Plan.

The following goals and objectives contained in the adopted 2005 Comprehensive Plan are pertinent to the issue of signage in the City.

Goal 2.0 New development in an established neighborhood will be compatible with the overall urban design and fabric of that neighborhood.

Objective 2.1 Ensure that the site design for new development in established neighborhood is compatible with the built fabric of that neighborhood.

Objective 2.4 Promote development that residents and visitors recognize as being of high quality and aesthetically pleasing.

Goal 3.0 New development should be consistent with Urbana’s unique character.

Objective 3.1 Encourage an urban design for new development that will complement and enhance its surroundings.

Goal 24.0 Enhance Urbana’s commercial areas.

Objective 24.1 Use a variety of economic development tools to improve and redevelop Urbana’s existing commercial areas.

Objective 24.2 Encourage the beautification of entryway corridors and major transportation corridors in Urbana.

Goal 26.0 Improve the appearance of Urbana’s commercial and industrial areas.

Objective 26.1 Use a variety of available economic development tools (such as tax increment financing) to improve the appearance and functionality of Urbana’s commercial and industrial areas.

Objective 26.2 Promote the beautification of commercial areas especially along University Avenue, Cunningham Avenue, and Philo Road.

Additionally the 2005 Comprehensive Plan contains the following pertinent implementation strategy:

- Amend the Urbana Zoning Ordinance to include updated sign regulations

Urbana Zoning Ordinance.

Urbana’s Comprehensive Sign Regulations are part of the City’s Zoning Ordinance. The stated intent of the Comprehensive Sign Regulations (Section IX-1 of the Zoning Ordinance) include establishment of regulations and controls which promote the goals, objectives, and policies of the City of Urbana’s Comprehensive Plan, and to permit and regulate signs in such a manner as to support and complement the land use policies set forth elsewhere in the Zoning Ordinance. To these ends, the Sign Regulations intend to:

- Aid in traffic safety by avoiding uncontrolled proliferation of signs which distract and endanger safety and traffic flow;
- Reduce congestion of land, air and space;
- Preserve and protect property values;
- Establish reasonable standards for the use of signs to maintain and encourage business activity;
- Protect and enhance the physical appearance of the community and the scenic value of the surrounding area; and

- Regulate signs visible from public properties where such signs could jeopardize the public’s investment in these facilities.

City Council Common Goals.

The following City Council common goal is pertinent to the issue of electronic sign lighting.

Implement the 2005 Comprehensive Plan.

- A. Rewrite our Zoning Ordinance. We propose hiring an outside consultant in order to accomplish this over the next year and to focus on billboards and sign issues now with current staff. [emphasis added]
- B. Include use of design guidelines, form-based code concepts, modern sign and lighting standards, Traditional Neighborhood Development standards, commercial big box store standards, neighborhood business zones, preserving historic neighborhoods, farmland, natural areas and minimizing sprawl as guiding principles (see Comprehensive Plan implementation section for complete action items and goals). [emphasis added]

Requirements of Other Municipalities

Some Illinois municipalities already require that digital signs have an automatic dimming device and/or establish a maximum brightness level. The following are examples.

City of Bloomington, Illinois

“All message centers will have a functional automatic dimming device, set to dim message centers at dusk equivalent of 20 watt lamp automatic operation. (Ordinance No. 1998-95)” (Chapter 3, Section 6.1)

City of Champaign, Illinois.

“Electronic outdoor advertising sign faces shall be equipped with a system to regulate the intensity of lighting, reducing or increasing the light output as exterior light conditions fluctuate.” (Sec. 37-412)

City of Evanston, Illinois.

“Brightness Limitation: In no instance shall the lighting intensity of any sign, whether resulting from internal illumination or external illumination, exceed:

- a. Seventy five (75) foot-candles measured perpendicular to the face of the sign from a distance equal to the narrowest dimension of the sign; or
- b. When the sign is located in a residential zoning district, fifty (50) foot-candles measured perpendicular to the face of the sign from a distance equal to the narrowest dimension of the sign; or

c. One foot-candle on adjoining residential property, measured three feet (3') above the surface of the ground. (Section 4-12-8)

City of Naperville, Illinois.

“Illuminated signs shall produce no more than thirty (30) foot-candles of illumination, four (4) feet from the sign.”

City of Peoria, Illinois.

(d) Automatic Dimming. Electronic multiple message signs shall be equipped with light sensing devices or a scheduled dimming timer which automatically dim the intensity of the light emitted by the sign during ambient low-light and nighttime (dusk to dawn) conditions. The signs shall not exceed 500 nits of intensity as measured at the sign surface during nighttime and low-light conditions and 5,000 nits during daytime hours.

(e) Maintenance. Electronic multiple message signs shall be properly maintained. Bulbs, LEDs, pixels and the like shall be in working, properly illuminating condition at all times. (Section 17.15)

Other municipal codes.

Daktronics has provided the attached “Positive Code Language” showing examples of other municipal sign illumination codes in the Great Plains, Midwest, and Rocky Mountain regions of the country.

Issues and Discussion

Alternatives

Two alternatives for a maximum light level are achievable, but both offer advantages and disadvantages.

Candela (NITS) standard

Pros

- Provides an objective standard which requires no judgment in administration and enforcement
- Easier enforcement in instances where property owners might be unwilling or unable to participate as it does not require the sign to be turned off and on to take readings.

Cons

- Does not take into account ambient light levels, meaning adjustment for day/night and sunny/cloudy conditions or other lighting. This can partially be addressed by establishing a maximum brightness standard only for night time.
- Expensive equipment. A Candela Meter (NITS gun) costs approximately \$3,000
- The Outdoor Advertising Association of America recommends against using this as a standard.

Footcandle standard

Pros

- Provides an objective standard which requires little to no judgment in administration and enforcement
- Takes into account ambient light levels under all conditions.
- Relatively inexpensive equipment. Footcandle meters cost \$100-\$1,000.
- Endorsed as an industry-wide standard by the Outdoor Advertising Association of America.

Cons

- More difficult enforcement in instances where property owners might be unwilling or unable to participate. In order to measure light levels, the sign must first be turned off and then turned on with an all white display. A partial solution for this situation would be, if necessary, the enforcement officer could have cardboard or plywood held to block the sign while a reading is taken. City staff believes that in most instances, sign operators would cooperate.

Given the benefits and drawbacks of the two alternatives, City staff recommends using the footcandle basis for an electronic sign lighting standard.

Proposed Text Amendment

The proposed amendment would revise Section IX-4 of the Urbana Zoning Ordinance by adding Paragraph 4 (illumination). In the following, words shown as underlined are proposed new. (The remainder of the text would remain unchanged but portions of the text are shown for context.)

Section IX-2. Sign and OASS Definitions

A. *Animation or Animated.* The movement or optical illusion of movement of a sign or its sign structure, design, or illumination, caused by any method other than physically removing and replacing the sign or its components. For the purposes of this Article, animation shall include mechanical, electrical, electronic, or other means, or the appearance of movement, including but not limited to full-motion video, flashing, scrolling, oscillating, blinking, twinkling, or changing color or light intensity in a way simulating change; provided that signs employing static electronic displays, changing instantaneously without swipes or transitions, and with a frequency of change no more than once every three minutes, shall not be defined as animated signs.

...

F. *Electronic Display:* Visual representation of text, graphics, and/or images through electronic means, either analog or digital, and whether by cathode ray tube, light emitting diode (LED), liquid crystal display (LCD), plasma, or any other electronic means.

L. *Internally Illuminated or Internal Illumination*: Having a light source that is concealed on contained within a sign and becomes visible in darkness through a translucent surface.

...

N. *Message Board*: A sign, or any portion of a sign, designed and constructed to allow changeable messages through manual, mechanical, or electronic means.

...

Section IX-4. General Sign Allowances

...

C. *Electronic Display*. Freestanding signs and wall signs authorized by this Article in the B-3, General Business Zoning District, may include an element of electronic display when designed and operated to meet the following requirements:

1. Area. The maximum area of electronic display shall not exceed 50 percent of any sign area.
2. Animation. Electronic displays shall not be animated as defined by this Article, including a minimum display change frequency of no more than once every three minutes.
3. The sign, including electronic display, shall meet all other design standards in this Article.
4. Illumination.
 - a. Electronic display signs shall be equipped with automatic dimming technology which adjusts the sign’s illumination level based on ambient light conditions.
 - b. The maximum illumination level of an electronic display shall be 0.3 foot candles above ambient light levels, to be measured as follows.

At least 30 minutes past sunset, and with the electronic display either turned off, showing all black copy, or blocked, a foot candle meter will be used to record the area ambient light level. An ambient reading will be taken with the meter aimed directly at the electronic display and at the following distance:

<u>Electronic sign size</u>	<u>Measurement distance</u>
0-100 square feet	100 feet
101-350 square feet	150 feet
351-650 square feet	200 feet

To establish the illumination level, the electronic display will be turned on to show all white copy and a second reading taken. The difference between the two readings shall be the electronic sign’s illumination level.

Summary of Staff Findings

1. Urbana's Zoning Ordinance has been enacted by the corporate authorities of the City of Urbana pursuant to its home rule powers as provided for in the Constitution of the State of Illinois, 1970, and in conformance with the Illinois Municipal Code.
2. Section IX-4.C of the Urbana Zoning Ordinance allows freestanding and wall signs to include electronic display but does not currently establish a maximum brightness level.
3. The proposed amendment is consistent with the goals and objectives of the Urbana Comprehensive Plan, the intent of the Zoning Ordinance, and furthers adopted City Council goals.
4. The proposed amendment to Urbana's Sign Regulations is intended to further the public interest by reducing glare, minimizing unreasonable driver distraction, improving the aesthetics of the community, and creating a level playing field for Urbana businesses.
5. The proposed amendment conforms to electronic sign light standards recommended by the Outdoor Advertising Association of America.
6. The proposed amendment is intended to assist in administration of the Zoning Ordinance.

Options

The Plan Commission has the following options for recommendations to the City Council. In Plan Case 2110-T-09, the Plan Commission may forward this case to the City Council with a recommendation to:

- a) Approve the Zoning Ordinance amendment;
- b) Approve the Zoning Ordinance amendment, as modified by specific changes; or
- c) Deny the Zoning Ordinance amendment.

Staff Recommendation

Based on the evidence presented in the discussion above, and without the benefit of considering additional evidence that may be presented at the public hearing, staff recommends that the Urbana Plan Commission forward this application to the City Council with the recommendation for **APPROVAL**.

Attachments:

- Exhibit A: OAAA Summary of Lewin Measurements
- Exhibit B: Lewin Report
- Exhibit C: "Positive Code Language" (Daktronics)



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MEMORANDUM

DATE: February 7, 2008

TO: Mary Marocco, Director of Real Estate
New York Department of Transportation

FROM: Myron Laible, VP, State, Local and Regulatory Affairs
Bill Ripp, Chair, OAAA Digital Subcommittee on Lighting

RE: Digital Billboards – Lighting Brightness Criteria

RE: Digital Billboards Brightness Recommendations and Measurement Techniques

The Outdoor Advertising Association of America (OAAA) has commissioned Dr. Ian Lewin, a principal at Lighting Sciences, Inc., Scottsdale, AZ, to recommend criteria for brightness levels on digital billboards. The standards are designed to minimize the risk of glare or unreasonable driver distraction. Highlights from the lighting research follow:

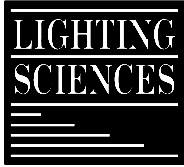
- The recommended criteria follows the lighting standards established by the Illuminating Engineering Society of North America (IESNA)
- Recommended regulatory criteria:
 - **Lighting levels will not increase by more than 0.3 foot candles (over ambient levels) as measured using a foot candle meter at a pre-set distance**
 - **Pre-set distances to measure the foot candles impact vary with the expected viewing distances of each size sign. Measurement distance criteria follows:**

Posters	150'
10'6x36 Bulletins	200'
14x48 Bulletins	250'
20x60 Bulletins	350'

- **Each display must have a light sensing device that will adjust the brightness as ambient light conditions change**

Background to support the regulations:

- The measurement distances were selected based on the average minimum viewing of any digital billboard.
- Enforcement: Standards can be easily enforced as follows:
 1. At least 30 minutes past sunset, use a foot-candle meter to record the ambient light reading for the area. This is done while the digital billboard is off or displaying all black copy.
 2. The reading should be taken with the meter aim directly at the digital sign at the appropriate pre-set distance.
 3. Turn on the digital display to full white copy and take another reading.
 4. If the difference between the readings is 0.3 foot-candles or less, the brightness is properly adjusted.
- These lighting standards will drop the night time brightness of the sign to approximately 4% to 15% of its capable output. The light output spread is due to the variation in the ambient lighting level of each location.
- The daytime brightness will operate near maximum output (7,500 nits), which is required to overcome full sunlight.



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April 8, 2009

Report to: International Sign Association

Subject: Electronic Message Center Sign Luminance

Executive Summary

Work has been carried out to develop recommendations for the maximum luminance (brightness) of digital signs operating at night.

The Illuminating Engineering Society of North America (IESNA) publishes guidelines for outdoor lighting, some of which provide suggested limits on the amount of light that a light source operating at night can produce when measured at the eyes of a viewer. These recommended limits change depending on the “environmental lighting zone;” for example higher footcandles at the eye are allowed in urban areas where there is much electric light, versus suburban areas that are darker.

A sample digital sign has been evaluated for its light output characteristics in a light measurement laboratory. From these tests, the light level produced by the sign at the location of a viewer a certain distance away can be calculated. A table has been developed giving the maximum sign luminance that can be produced in the various environmental lighting zones such that the light level at the viewer’s eyes does not exceed the applicable limit per the IESNA recommendations

The recommendations have been developed for a sign area of 100 sq. ft. when viewed from a distance of 100 ft. The rationale for this choice is provided in the report. It has also been assumed that the sign is producing an all-white display, representing the brightest case.

Using the methodology developed, an all-white sign is recommended to operate at a maximum luminance of 323 nits in an area of low ambient brightness, or 861 nits in an area of medium ambient brightness. These represent 4.6% and 12.3% respectively of the output of the typical sign that was measured.

Methods of measuring sign light outputs are addressed in the report, and an appendix describes the lighting units and relationships involved.

1. Background

Commercial signs employ a considerable variety of light source types. Various forms of lamps that are in use include fluorescent, neon, incandescent and High Intensity Discharge (mercury, metal halide or High Pressure Sodium) types. New signs may use LED's, or Light Emitting Diodes. Conventional signs have a fixed message: The lamps illuminate lettering or other display forms that usually do not have the ability to change what is displayed. In cases where a changing display is provided, this is usually achieved by simple on/off switching or dimming of certain parts of the sign.

Digital signs are a relative new form of signage where the sign face consists of a multitude of closely spaced dots of light, or picture elements (usually abbreviated to "pixels.") The pixels are red, blue and green, or monochrome/grayscale. In a manner equivalent to a television screen, by switching on the various color pixels in desired patterns and brightnesses, virtually any message can be created as a colored picture on the sign face. Such signs are driven by a computer with the on/off and brightness of each pixel at any moment controlled electronically by the computer program. Such devices are therefore frequently referred to as "Electronic Messaging Center" signs, (EMC).

A great advantage of EMC signs versus conventional signs is that sign messages, once programmed, can be changed as desired. Multiple messages can be provided with ease.

A further feature of EMC signs is that sign luminance, or brightness, can be controlled and varied. A high brightness normally is necessary during daytime hours to provide acceptable legibility. However, the same luminance used at night may be excessively bright, but controls provided in the computer software and associated electronics allow the brightness to be reduced to an acceptable level for nighttime usage. This can be assisted by the use of an auxiliary photocell on or near the sign, which detects the level of ambient light and feeds the measurement to the computer so that automated nighttime dimming is provided.

A significant question is "What level of sign brightness is acceptable at night?" A sign with too high a brightness level may be found objectionable by the public. A sign not bright enough may not provide satisfactory sign attention or legibility. Further, the nighttime brightness level that may be considered satisfactory in one area of a city may be unsuitable in a different area, depending on the ambient light or "competition" from other signage.

This report addresses these concerns and provides recommendations for sign light levels suitable for use at night. It does not cover factors related to changing images and sign message movement. Issues that may be related to motorists and their attention have not been investigated and use of the proposals in this study should be based on that understanding.

2. Sign Testing

As part of the evaluation of digital sign performance, a sample sign was obtained from Young Electric Sign Co., (YESCO. This was a Prism electronic display with a 20 mm pixel spacing driven by a suitable controller and computer. The sign was tested for its light output characteristics at the

laboratories of Lighting Sciences Inc. Standard testing procedures were used in accordance with publication LM-35-02 (Reference 1), where the sign was placed on a goniophotometer, Lighting Sciences' model 6440, in a suitably equipped photometric dark room. The range of measurement angles was $\pm 90^\circ$ vertical and $\pm 90^\circ$ horizontal. Test distance was 8 meters. Test data collected was in terms of luminous intensity distribution, from which all other lighting quantities can be calculated for any desired distance. A range of tests was run with the sign producing an all white display (6800 K), and all red, all blue and all green displays. Sign brightness versus the dimmer settings was evaluated. Measurements were conducted for a complete range of angles of view. Reports on the complete performance characteristics of the sign were produced. These were used in this project to assist in producing the recommendations developed later in this report. Appendix C provides a test report in industry standard format per LM-35-02, Reference 1, along with the measured dimmer settings. Appendix D provides the raw intensity data in industry standard IES format per publication IESNA LM-63-2002, Reference 2. (Electronic version available by contacting author.)

3. Lighting Quantities

Some basic knowledge of the quantities used to measure light is needed to understand how sign specifications can be developed. These are briefly summarized below; a more detailed coverage is provided in Appendix A.

Luminance. This is a measure of the brightness of the sign face. The units are "nits." Sign brightness can be measured by aiming a special meter, called a "nit gun," at the sign face from a viewer's location.

Illuminance, measured in footcandles. This is the amount of light that is intercepted by an object that is a distance away from the sign. That is, the lighted sign face illuminates objects that are away from it, and the lighting level produced by the sign on a particular object is measured in footcandles. For example, persons viewing the sign from a particular location will have a certain footcandle level falling on their eyes due to the light rays emitted by the sign.

A footcandle meter placed at the viewer's eye location will measure the received illuminance.

The footcandle level at the viewer's eye will be dependent on several factors:

The luminance or brightness of the sign

The distance from the sign to the viewer. Higher footcandles are produced at locations close to the sign.

The area of the sign. A 4x4 ft. sign will produce four times the footcandle level of a 2x2 ft. sign, all other factors being equal.

The angle at which a sign is viewed will influence the luminance that will be seen, and also will affect the footcandle level it produces at a given location. For simplicity, this report assumes that signs are being viewed from a direction perpendicular to the face of the sign. (This is the condition that shows the highest sign face luminance. This is true for all off-axis angles of view, whether vertical or horizontal or any oblique angle; sign output is maximum along the perpendicular to the face - see Appendix C.)

Appendix A provides formulas that relate sign luminance (brightness), sign area, viewer distance, and illuminance (footcandles) produced at a viewer's eyes.

Figure 1 and 2 illustrate the measurement of sign brightness, and footcandles at a distant location.

4. Avoiding Potential Problems

Outdoor lighting at night will usually create benefits, but if not well designed, can produce problems. The purpose of developing guidelines for digital sign lighting is to provide the benefits of digital imaging while ensuring that potential problems are avoided.

Environmental Lighting Zones

The goals of signage of any type are for the signs to be conspicuous, visible and legible. To achieve this, the brightness of the sign needs to be appropriate for the area in which it is used. A dimly lighted sign in a high ambient brightness urban area likely will not meet its purpose, yet may be perfectly acceptable in a low ambient brightness rural area. The brightness of a sign, therefore, needs to be attuned to the area where it is being used, and in particular to the general lighting levels that are prevalent. Some cities are now assigning Environmental Lighting Zones, where the cities are divided in accordance with the general ambient lighting levels that are in use. It will be useful to take this zoning into account when developing and assigning sign brightness recommendations or limitations. This is addressed in more detail below.

Glare

In cases of excessive brightness of outdoor lighting fixtures, glare can be created. For example, if an EMC is run at night at brightness levels that are typical and appropriate for daytime use, the result at night can be glary. Sign brightness limits must set the sign brightness level low enough such that the sign cannot create glare.

Light Trespass

Light trespass can be created at night when a lighting device illuminates areas where such lighting is not required or desired. A lighted sign should provide a legible message to viewers and, avoid excessive sign brightness.

If sign brightness is controlled to levels that ensure that light trespass onto neighboring areas is limited to an acceptably low level, glare from the sign should not be an issue. Therefore, by developing sign brightness recommendations based on accepted industry standards, as described below, both light trespass and glare will be effectively eliminated. By using sign brightness levels that are sufficient but not too high, the necessary conspicuity, visibility and message legibility can be achieved. These are the principles of the sign brightness recommendations developed in this report.

“Light trespass” is a term used in the outdoor lighting industry to describe light that falls outside of an area that is primarily intended to be lighted. For example, if a pole-mounted lighting system for a shopping center parking lot causes undesirable light to spill over into an adjacent residential neighborhood, this would be considered to be light trespass. High levels of light trespass, as well as being wasteful of energy, may have an appearance that is objectionable. The Illuminating Engineering Society of North America (IESNA), the “Lighting Authority,” has addressed such issues. Publication TM-11-00 (Reference 3) of the IESNA provides a table of limits of light trespass for various environmental lighting zones. These zones range from “no ambient electric light” (dark rural areas) to “high ambient electric light” (typically high use urban areas.) The limits are expressed in terms of the illuminance in footcandles that the light source in question can produce at a person’s eyes, measured above the ambient lighting that is produced by all other sources of light. The limitation values were determined from an extensive human factors research project (Reference 4) into the levels of light trespass that may or may not be considered objectionable in the various zones. Application of the limits keeps light trespass to a low level that is unlikely to be considered objectionable to most persons.

Digital signs are not the form of lighting that TM-11-00 was developed to address. In fact, digital signs are specifically intended to be seen over a wide area, much of which may be remote from the sign itself. Nevertheless, the principles of TM-11-00, in terms of the calculation method and the limits it provides, give a methodology that forms a useful method of specifying sign luminance (brightness) limits.

Numerous calculations have been performed to evaluate sign luminance in terms of the TM-11-00 procedures. The calculations involve determining the illuminance in footcandles (fc) at the location of the eyes of a viewer. (Referred to as “eye illuminance.”) TM-11-00 provides different eye illuminance limits depending on the lighting zone, LZ1 to LZ4, ranging from low ambient electric light to high ambient electric light. See table 1. (There is also LZ0 where there is no ambient lighting. The latest description of each type of ambient electric light zone is included in Appendix B.)

Table 1 Eye Illuminance Limits (Light Produced by Sign, above Ambient)		
Zone		Eye Illuminance Limit (fc)
LZ1	Low ambient electric light	0.1
LZ2	Moderate ambient electric light	0.3
LZ3	Moderately high ambient electric light	0.8
LZ4	High ambient electric light	1.5

For example, if a sign is located in an area of moderate ambient light, zone LZ2, the eye illuminance limit is 0.3 footcandles. That is, at a chosen viewer location, the sign should not produce more than 0.3 fc at the viewer's eyes. This can be easily checked: The eye illuminance at the chosen point is measured using a footcandle meter with the sign off, and remeasured with the sign on at whatever dimming setting is being evaluated. Measurement of an all-white display will provide the worst-case conditions. i.e. If an all-white sign meets this condition, all other displays also will comply. The increase caused by switching on the sign should not exceed 0.3 fc.

Providing that a method is available to calculate the sign luminance that will generate a certain illuminance at the eye of a viewer, it can be determined what sign luminance is allowable while not exceeding the eye illuminance limits of TM-11-00. The setting for the signs dimming control then can be easily found. The formula relating sign luminance and eye illuminance (footcandles at the eye) is developed in Appendix A, and is discussed in the next section.

5. Determining the Maximum Allowable Sign Luminance.

Sign luminance (which refers to the *average* luminance or brightness of the sign) is expressed in candelas per square meter, cd/sq.m., otherwise termed "nits." The illuminance produced at the eye, considered as landing on a vertical plane at the eye, is designated E_v and is measured in footcandles. (See Appendix A)

To determine the maximum sign average luminance, L , that can be allowed so as to meet a given illuminance limit at the viewer's eye, E_v , the following must be known:

- Area of sign = S sq. ft.
- Distance from sign center to observation point = D feet (as measured from a plan view. Differences in height of the sign and viewer normally can be disregarded, as can lateral angle effects from the sign face.)

Using equation A5 from Appendix A:

$$\text{Allowable maximum sign luminance, } L = \frac{10.76 D^2 E_v}{S} \quad \text{cd./sq.m. (nits)}$$

For example, to determine whether a sign meets a particular limit for the IESNA publication TM-11-00, the following steps are taken:

1. Select the applicable lighting zone from table 1 above.
2. Find the applicable eye illuminance limit from table 1. For example, if zone LZ2 is assumed, this will be 0.3 fc.
3. Determine the sign size. Assume for example a sign having an area of 100 sq. ft. (See discussion below).
4. Assume a distance to the viewer. Use 100 ft. (See discussion below).

These values are entered into formula 1 above.

$$\begin{aligned} \text{Allowable maximum sign average luminance} &= \frac{10.76 \cdot 100^2 \cdot 0.3}{100} \\ &= 323 \text{ cd/sq.m. (nits)} \end{aligned}$$

From this example calculation, it is determined that a 100 sq. ft. sign having a luminance of 323 nits will meet the IESNA recommended limit for a lighting zone LZ2 for a viewer located 100 ft. from the sign. Any sign having a luminance lower than 323 nits, of course, similarly would meet the IESNA limitation.

6. Variables to Be Considered: Viewer Distance

6.1 Viewer Distance

The distance from the sign to the viewer, D in the above formula, has a significant effect on the calculated allowable maximum sign luminance. Signs are typically viewed over a range of distances, and so the choice of the value of D will be somewhat arbitrary.

It is proposed to use a standard distance of 100 feet to develop sign luminance recommendations through the above form of calculation. The rationale for this recommendation is as follows:

- Choosing a reasonable but small distance such as 100 ft. protects against overly bright signs. If a large distance were to be used, the calculated allowable sign luminance limits would be high, and could be considered too bright by some viewers who may be located at a smaller distance.

- Based on an average sign size of 100 sq. ft. as in the above calculation, the luminance limit would be set at 323 nits. *By experience and through field evaluation, luminance levels of this order have been found to produce highly acceptable legibility, conspicuity and visibility, while avoiding over-brightness.* (Reference: Field evaluation studies carried out by Lighting Sciences Inc. and the International Sign Association).

In summary, standardizing on a viewer distance of 100 ft. for the calculations can be expected to satisfy the needs of both the sign operators and the general public, which is the goal of this research.

6.2 Sign Size

Digital signs are used in a variety of different sizes, ranging from small sizes of about 24 sq. ft up to large highway signs of 250 sq. ft. (Even larger sizes as may be used as digital billboards are not considered in this report.)

It is impractical to develop a different sign luminance specification for every different possible size of sign. It is proposed to use a 100 sq. ft. sign as a standard in the above form of calculation for practicality and simplicity.

Signs smaller than 100 sq. ft. will even more easily meet the IESNA recommendations presented above, thus meeting the desired goals. Larger sizes of sign will typically be used on highways where the distance to the viewer is greater than the proposed standard distance of 100 ft., and because of this will likely meet the IESNA limitations at typical viewer distances.

Not only is it logical to use a moderate sign size of 100 sq. ft., but as shown by the illustrative calculation provided above, calculations yield a sign luminance limit that has been found practical and desirable in field evaluations.

6.3 Lighting Zones

The above example calculation is based on lighting zone LZ2 per IESNA specifications and indicates a luminance limit of 323 nits. Other lighting zones have different limits per the IESNA table, and equivalent calculations for these zones provide the following luminance limits:

Table 2 100 sq. ft. Sign at a Distance of 100 Feet		
Sign Luminance Limits		
Zone	Eye Illuminance Limit (fc) per IESNA	Sign Luminance Limit (Nits)*
LZ1	0.1	108
LZ2	0.3	323
LZ3	0.8	861
LZ4	1.5	1615

*Based on the proposed standard conditions of viewing a 100 sq. ft. sign at a distance of 100 ft. Appendix E provides similar tables for other sign sizes, but these are not part of the proposed specification procedures. See also section 10 that deals with different sign size.

It can be seen from Table 2 that sign brightness can be increased considerably when the sign is in an area of moderately high or high ambient light while still meeting the IESNA criteria. It is cautioned that the level of 1615 nits for an LZ4 area is likely to be considerably higher than is desirable to provide optimum legibility.

It is proposed that the following luminance limits should be adopted as follows:

Areas of low ambient electric light	108 nits	(0.1 fc at 100 ft. for a 10 x 10 ft. sign)
Areas of moderate ambient electric light	323 nits	(0.3 fc at 100 ft. for a 10 x 10 ft. sign)
Areas of moderately high and high electric light	861 nits	(0.8 fc at 100 ft. for a 10 x 10 ft. sign)

Before adoption of these values, Lighting Sciences Inc. advises that field evaluations of EMC signs should be conducted to verify that such levels produce the desired attention-gathering legibility and public acceptance.

7. Sign Dimming Settings for Nighttime Use

Laboratory evaluations for signs used in this study showed that, when operated at 100% manufacturer recommended luminance for a 6800 K white display, the sign will produce around 7000 nits. (Note: Different signs will vary in their maximum luminance output.) The following formula can be used to determine the dimming setting to be used for any desired luminance:

$$\text{Dimming setting \%} = \frac{\text{Required Luminance}}{\text{Luminance at 100\% Setting}} \times 100$$

For the above referenced sign, to meet the luminance limits developed in Table 2 for lighting zones LZ1, LZ2 and LZ3/LZ4, dimming settings as given in table 3 should be used. Note that different signs will require different dimming settings based on their specific maximum luminance output.

Table 3		
Dimming Settings Based on Case Study		
Lighting Zone	Sign Illuminance Limit (Nits)	Dimming Setting
LZ1	108	1.5%
LZ2	323	4.6%
LZ3 or LZ4	861	12.3%

8. Non-white EMCs

If the digital image will never be totally white, higher % dimming settings can be used while still meeting the luminance limit. The actual measured luminance values for the sample sign for a 100% luminance setting for different colors are:

White, 6800K	7000 cd/sq.m.
Red	1500 cd/sq.m.
Green	5100 cd/sq.m.
Blue	700 cd/sq.m.

For a normal image that includes multiple colors, the average luminance for a 100% setting will depend on the proportion of colors in the mix. Software and instrumentation is available to analyze sign luminance when the sign is being programmed.

For example, if a sign is completely green rather than white, the dimmer setting can be increased by a factor of $7000/5100 = 1.37$ while still meeting the maximum luminance limitation.

9. Adoption of the Method

This method uses the established and recommended procedures of IESNA to develop sign luminance limits. The limits of TM-11-00 (Reference 3) were established through research conducted by Lighting Sciences Inc. under a contract from the Lighting Research Office of EPRI (Electrical Producers' Research Institute). (Reference 4) The basis of TM-11-00 was subsequently provided to IESNA to form the publication. Field use of the values for various forms of outdoor lighting confirm that the values are realistic and prevent undue annoyance to a majority of viewers, and thus appear to have formed a satisfactory basis for specifying such lighting limits.

The values provided in table 3 of this report are recommended by Lighting Sciences Inc. for evaluation by the International Sign Association.

10. Post-Evaluation

After a sign is installed, there will be cases where it is desired to evaluate the sign luminance to ensure that it does not exceed the specified value. This procedure is extremely simple and requires only a footcandle meter.

The sign luminance specification is based on ensuring that a certain footcandle level created by the sign is not exceeded at a chosen distance. Thus all that is needed to check compliance is the measurement of the footcandle level at that distance with the sign on and off. The footcandle meter is held at a height of 5 ft. (which is approximately eye height) and faces directly towards the sign,

from a distance of 100 ft. When conducting this check, the meter should be at a location perpendicular to the sign center (as seen in plan view) as this angle has the highest luminance.

If the area is LZ2, for example, and the sign size happens to be the standard size of 100 sq. ft., the difference in footcandle readings should be 0.3 fc or less. This value is 0.8 fc for LZ3 and LZ4 zones if the Table 3 limits are being used.

If the sign size is other than 100 sq. ft., the measured reading needs to be prorated to what an otherwise identical sign of 100 sq. ft. area would produce:

$$\text{Prorated footcandles} = \text{Measured footcandles} \times \frac{100}{\text{sign area (sq. ft.)}}$$

The prorated measured footcandle value is then used to compare to the 0.3 or 0.8 fc limit.

Example: Evaluation of a 200 sq. ft. sign. Say the measured illuminance at 100 ft. is 1.0 fc above ambient. i.e. With sign on and showing an all white display, the reading at 100 ft. is 1.0 fc greater than with the sign off.

$$\begin{aligned} \text{The Prorated footcandles} &= 1.0 \times \frac{100}{200} \\ &= 0.5 \text{ fc} \end{aligned}$$

In this example, the sign meets the requirement for zone LZ3 because its prorated footcandles are less than 0.8 fc, but it does not meet the recommended condition for zone LZ2 because the prorated footcandles exceed 0.3 fc.

Checks should be made using an all white image displayed by the sign in order to evaluate the worst case condition.

11. Summary of Proposed Method

Specification based on the light trespass limits adopted by IESNA in publication TM-11-00 appears to provide a manageable and technically viable method. This has been used to develop the sign luminance limits and dimming settings provided in table 3, which are suggested for field evaluation by ISA members.

Because the sign luminance values have been derived from IESNA publication TM-11-00, which in turn is based on an extensive human factors research project, adoption of such values should satisfy the requirement that most persons will not find these sign luminance values to be objectionable. Field evaluation has indicated that such levels will provide conspicuity, visibility and legibility.

Ian Lewin Ph.D., FIES, L.C.
October 3, 2008 April 8, 2009

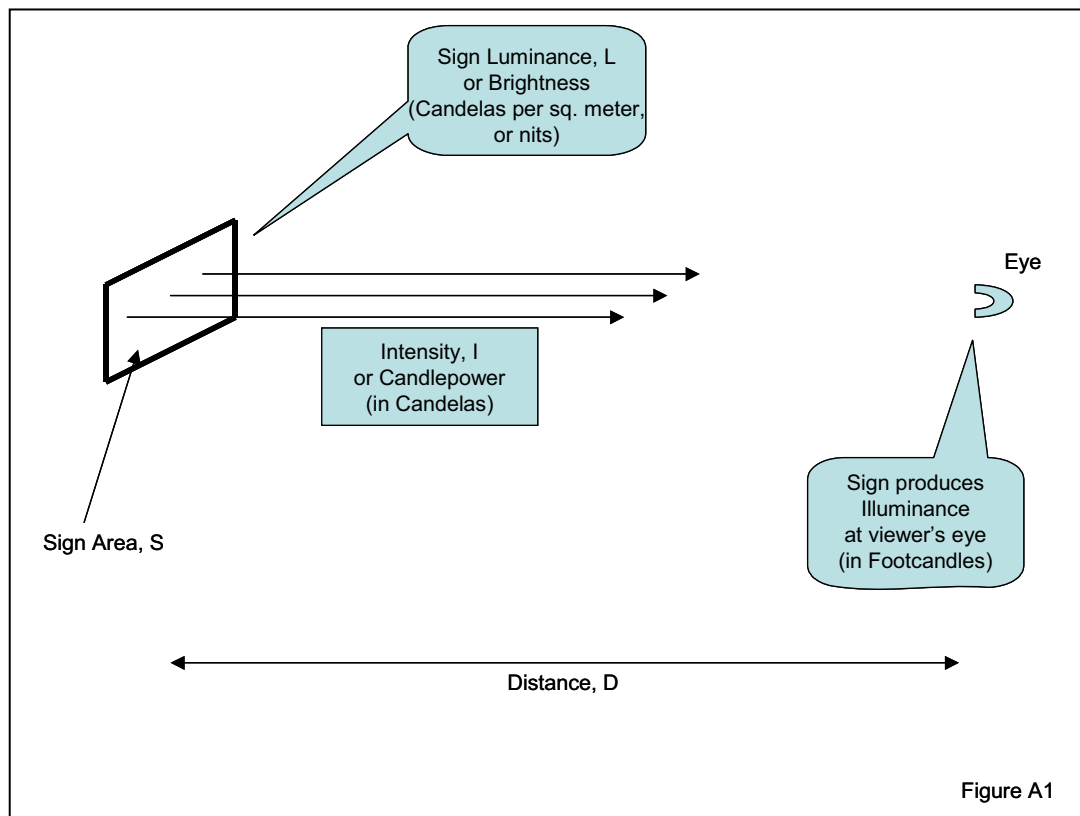
References

1. *IESNA Approved Method for Photometric Testing of Floodlights Using High Intensity Discharge or Incandescent Filament Lamps*. Publication LM-35-02, Illuminating Engineering Society of North America, New York, 2002
2. *IESNA Standard File Format for the Electronic Transfer of Photometric Data and Related Information*. Publication LM-63-03, Illuminating Engineering Society of North America, New York 2002.
3. *Light Trespass : Research, Results and Recommendations*. Publication TM-11-00. The Illuminating Engineering Society of North America. New York, NY. December 2000.
4. *Light Trespass Research*. EPRI Report No. TR-114914, March 2000. Lighting Research Office of the Electric Power Research Institute. EPRI Customer Service Assistance Center, Palo Alto, California. (1-800-313-3774).

Appendix A

Lighting Units and Terms

Several terms are useful in describing the light characteristics of digital signs. See figure A1.



Candlepower. This is the intensity, I , of light produced by the sign in a particular direction, and it is measured in “candelas.” For example, a sign of a certain size will emit a certain intensity of light in a direction perpendicular to its face. The intensities emitted in other directions will be less than that in the perpendicular direction. If the sign displays a white image, this intensity will be higher than if the sign face is any other color.

Candlepower does not change significantly with distance, providing the atmosphere is clear; the intensity continues as the light rays move in a straight line until they strike a surface.

Luminance, L , often called “brightness,” relates to the overall appearance of the sign. It is the candlepower emitted per unit area, and is expressed in units of “candelas per square meter,” or $\text{cd}/\text{sq.m}$. Say a sign that has an area of 2 square meters produces 400 candelas when viewed from a

direction perpendicular to its face, then its luminance is $400/2$, equal to 200 cd/sq.m. The term “nit” is also used. Such a sign is said to have a brightness of 200 nits.

The formula relating the sign size, luminance (or brightness) and the candlepower it projects is:

Candlepower (in candelas) = Luminance (in candelas/sq.m. or nits) x sign area (in square meters)

or
$$I = L \times S \quad \text{_____ A1.}$$

(L is in nits, S is in sq.m.)

Illuminance, E. This is a measure of the amount of light that is intercepted by an object that is illuminated by the sign. Illuminance is measured in “footcandles,” and is dependent on the distance from the sign, as well as the candlepower the sign produces. If a viewer is looking at the sign, the illuminance at the viewer’s eye, E_v , can be found using the “Inverse Square Law,” which states

$$\text{Illuminance (in footcandles)} = \frac{\text{Candlepower (in candelas)}}{\text{Distance}^2 \text{ (in feet)}}$$

or
$$E_v = \frac{I}{D^2} \quad \text{_____ A2.}$$

The value of I from equation 1 can be substituted into equation 2 to give

$$E_v = \frac{L \times S}{D^2} \quad \text{_____ A3.}$$

Equation 3 is very useful because it relates sign size (S), sign luminance (or brightness) (L), and gives the footcandles (E_v) that will be produced by the sign at a distance, D feet. It can be rewritten:

$$L = \frac{D^2 E_v}{S} \quad \text{_____ A4.}$$

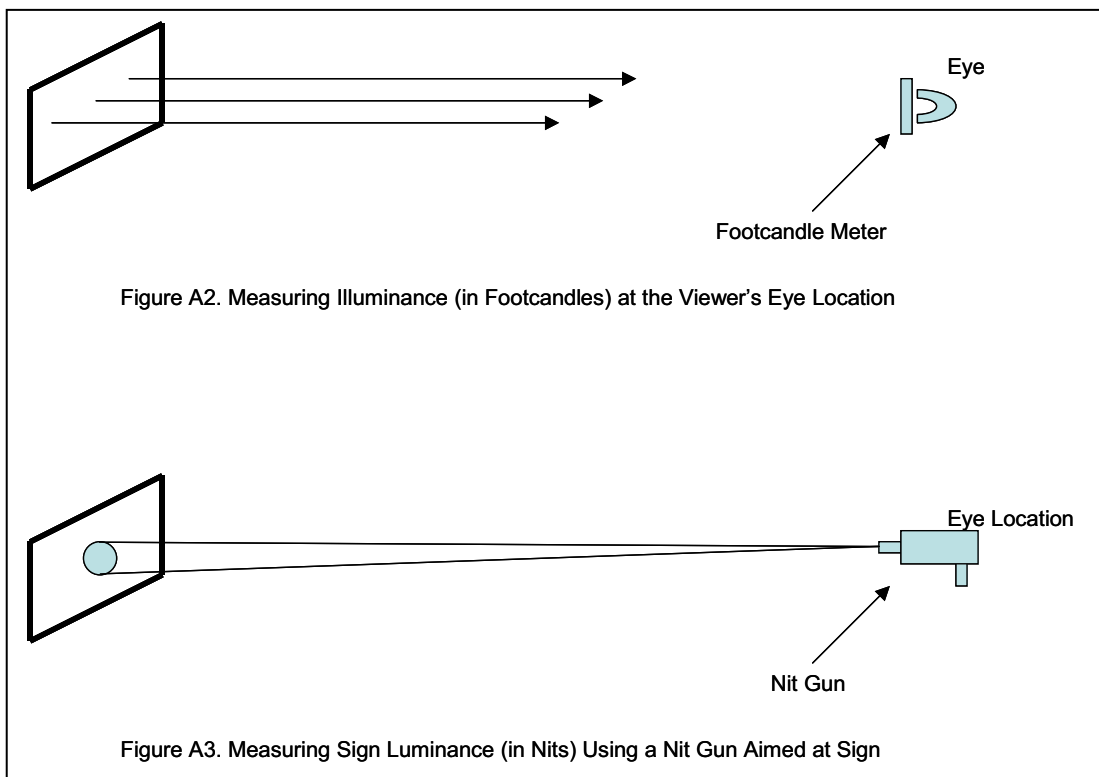
L is in nits, E_v is in footcandles,
D is in feet, S is in sq. meters

Otherwise, if the area of the sign, S, is in square feet, the equation becomes

$$L = \frac{10.76 D^2 E_v}{S} \quad \text{A5.}$$

L is in nits, E_v is in footcandles,
D is in feet, S is in sq. feet

The illuminance, E, can be measured easily with a relatively inexpensive footcandle meter at a measured distance D feet from the sign. Figure A2. The area of the sign, S, presumably is known. Inserting these values of E, D and S into equation 5 allows the luminance, L in nits, to be calculated.



L, the sign brightness, can also be measured with a “nit gun”, which is a luminance meter that can be pointed at the sign. Figure A3. However such devices are more expensive and less readily available than a footcandle meter.

Because of the simple relationship as given in equation 5, sign luminance specifications can be written in terms of footcandle limitations at a certain distance. For compliance checking, if the footcandle value produced by the sign and measured at a prescribed distance is at or below a specified level, then it will be known that the sign luminance meets the desired limitation.

Appendix B

Description of the Lighting Environmental Zones (from IESNA*)

LZ0: No ambient lighting

Areas where the natural environment will be seriously and adversely affected by lighting. Impacts include disturbing the biological cycles of flora and fauna and/or detracting from human enjoyment and appreciation of the natural environment. Human activity is subordinate in importance to nature. The vision of human residents and users is adapted to the total darkness, and they expect to see little or no lighting. When not needed, lighting should be extinguished.

LZ1: Low ambient lighting

Areas where lighting might adversely affect flora and fauna or disturb the character of the area. The vision of human residents and users is adapted to low light levels. Lighting may be used for safety and convenience but it is not necessarily uniform or continuous. After curfew, most lighting should be extinguished or reduced as activity levels decline.

LZ2: Moderate ambient lighting

Areas of human activity where the vision of human residents and users is adapted to moderate light levels. Lighting may typically be used for safety and convenience but it is not necessarily uniform or continuous. After curfew, lighting may be extinguished or reduced as activity levels decline.

LZ3: Moderately high ambient lighting

Areas of human activity where the vision of human residents and users is adapted to moderately high light levels. Lighting is generally desired for safety, security and/or convenience and it is often uniform and/or continuous. After curfew, lighting may be extinguished or reduced in most areas as activity levels decline.

LZ4: High ambient lighting

Areas of human activity where the vision of human residents and users is adapted to high light levels. Lighting is generally considered necessary for safety, security and/or convenience and it is mostly uniform and/or continuous. After curfew, lighting may be extinguished or reduced in some areas as activity levels decline.

*Descriptions current as of April 2009. Expected to be adopted as final by IESNA.

Appendix C

Photometric Test Report on
YESCO 20mm Prism Electronic Display



CERTIFIED TEST REPORT NO. LSI 21628F

YESCO - LED 12.6" X 12.6" DIGITAL SIGN
RED GREEN BLUE LED ARRAYS AT 20mm SPACING
OPERATING IN WHITE MODE AT 6800K

FLOODLIGHT SUMMARY

FIELD ANGLE (BASED ON 10% OF MAX. CP.)	149.2H X 72.5V
BEAM ANGLE (BASED ON 50% OF MAX. CP.)	103.0H X 43.8V
IESNA & NEMA TYPE	7H X 5V
MAX. INTENSITY (CANDLEPOWER)	710 Candela
MAX. CP. VERT. ANGLE	0.0 Degrees
MAX. CP. HORIZ. ANGLE	0.0 Degrees
FIELD LUMENS	769 Lms.
FIELD EFFICIENCY	96.1 Percent
BEAM LUMENS	572 Lms.
BEAM EFFICIENCY	71.4 Percent
TOTAL LUMENS	800 Lms.
SPILL LIGHT LUMENS	31.1 Lms.

DATE: Oct 29 2008

FIELD ANGLE IS DEFINED BY 10 PERCENT OF MAX. INTENSITY (CANDLEPOWER)
BEAM ANGLE IS DEFINED BY 50 PERCENT OF MAX. INTENSITY (CANDLEPOWER)

LABORATORY RESULTS MAY NOT BE REPRESENTATIVE OF FIELD PERFORMANCE
BALLAST FACTORS HAVE NOT BEEN APPLIED

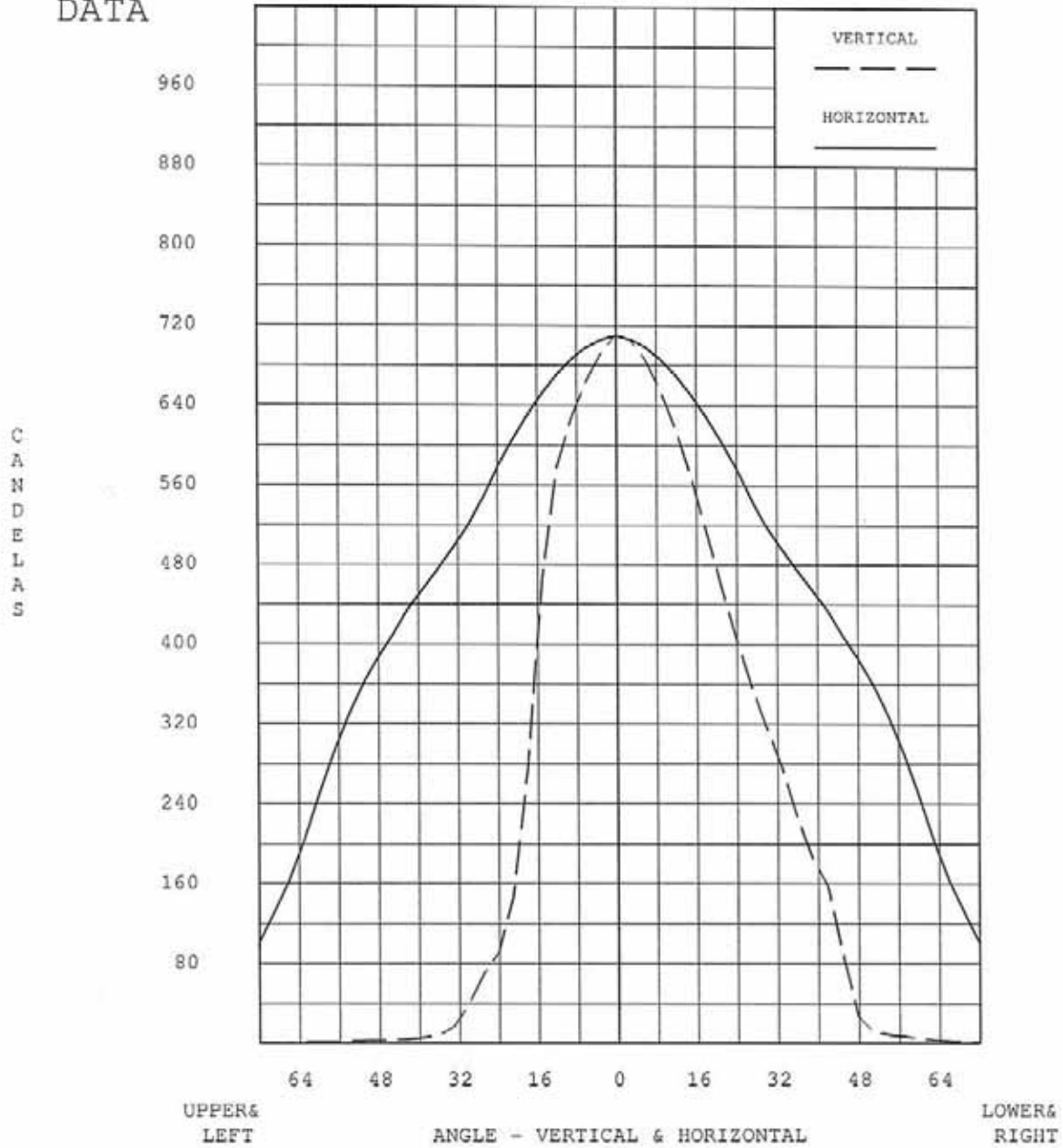
TESTED AND COMPUTED IN ACCORDANCE WITH IESNA LM-35-02
TEST DISTANCE IS 8 METERS (26 FEET) OR MORE

CERTIFIED TEST REPORT NO.21628F

YESCO - LED 12.6" X 12.6" DIGITAL SIGN
RED GREEN BLUE LED ARRAYS AT 20mm SPACING
OPERATING IN WHITE MODE AT 6800K

FLOODLIGHT DATA

CANDLEPOWER THROUGH ORIGIN



TEST No. 21628F
STANDARD TABLE OF CANDELAS AND LUMENS

ANGULAR DATA IS SHOWN WITH THE POLAR AXIS HORIZONTAL.

LUMINOUS INTENSITY IN CANDELAS AT CENTERS OF ZONES.

LUMINOUS FLUX IN LUMENS IN ZONES.

***** MULTIPLY CANDELAS BY 1 *****

LUMEN RATING: 801 Lms.

RIGHT HAND COLUMN SHOWS LUMEN TOTAL FOR ONE SIDE ONLY, 0 TO 90 Degrees

VERT. ANGLE	HORIZONTAL ANGLE - DEGREES																							
	1.0	3.0	5.0	7.0	9.0	11.0	13.0	15.0	17.0	19.5	22.5	25.5	29.0	33.0	37.5	42.5	47.5	55.0	65.0	75.0	85.0	90.0		
90.0	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.00	
85.0	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.00	
80.0	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.00	
75.0	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.00	
70.0	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	0.08	
65.0	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.00	
60.0	4.1	4.1	4.1	4.1	4.1	4.1	4.1	4.1	4.1	4.1	4.1	4.1	4.1	4.1	4.1	4.1	4.1	4.1	4.1	4.1	4.1	4.1	0.57	
55.0	0.01	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.00	
50.0	11.1	10.1	9.1	10.1	9.1	9.1	9.1	9.1	9.1	9.1	9.1	9.1	9.1	9.1	9.1	9.1	9.1	9.1	9.1	9.1	9.1	9.1	1.30	
47.5	0.021	0.051	0.041	0.041	0.041	0.041	0.041	0.041	0.041	0.041	0.041	0.041	0.041	0.041	0.041	0.041	0.041	0.041	0.041	0.041	0.041	0.041	0.00	
45.0	85.1	75.1	66.1	69.1	70.1	72.1	72.1	70.1	69.1	70.1	69.1	66.1	69.1	66.1	64.1	64.1	65.1	61.1	55.1	42.1	21.1	0.04	0.00	
42.5	0.131	0.23*	0.24*	0.21	0.21*	0.21*	0.21*	0.21*	0.20	0.25	0.20	0.25	0.20	0.23	0.24	0.26	0.27	0.35	0.44	0.42	0.21	0.04	0.00	
40.0	174.1	170.1	168.1	165.1	164.1	163.1	163.1	162.1	160.1	159.1	154.1	148.1	145.1	142.1	134.1	128.1	122.1	113.1	93.1	62.1	19.1	0.1	11.53	
37.5	0.24	0.52	0.50	0.50	0.49	0.49	0.48	0.48	0.47	0.46	0.42	0.49	0.46	0.41	0.34	0.28	0.22	0.16	0.11	0.07	0.05	0.01	0.00	
35.0	236.1	228.1	224.1	224.1	223.1	222.1	220.1	219.1	218.1	215.1	211.1	205.1	200.1	194.1	184.1	175.1	163.1	151.1	122.1	78.1	23.1	1.1	14.03	
32.5	0.32	0.63	0.61	0.61	0.61	0.60	0.59	0.58	0.57	0.70	0.81	0.77	0.85	0.81	0.84	0.82	0.79	0.71	0.63	0.51	0.37	0.06	0.00	
30.0	302.1	294.1	292.1	292.1	291.1	290.1	289.1	288.1	285.1	282.1	277.1	269.1	260.1	251.1	241.1	224.1	208.1	187.1	146.1	92.1	27.1	1.1	16.03	
27.5	0.37	0.72	0.72	0.72	0.70	0.70	0.69	0.68	0.67	0.82	0.94	0.89	0.99	1.05	1.08	1.05	0.99	0.89	0.71	0.61	0.46	0.06	0.00	
25.0	351.1	343.1	342.1	342.1	341.1	340.1	339.1	336.1	334.1	330.1	324.1	314.1	304.1	294.1	280.1	263.1	242.1	215.1	167.1	101.1	28.1	1.1	18.34	
22.5	0.37	0.72	0.72	0.72	0.71	0.71	0.70	0.68	0.68	0.84	0.97	0.92	1.01	1.07	1.10	1.07	0.92	0.89	0.69	0.57	0.37	0.05	0.00	
20.0	402.1	391.1	392.1	391.1	390.1	389.1	387.1	384.1	381.1	376.1	369.1	356.1	343.1	331.1	314.1	296.1	271.1	240.1	182.1	104.1	29.1	1.1	15.82	
17.5	0.37	0.71	0.72	0.71	0.71	0.70	0.69	0.68	0.67	0.82	0.94	0.89	0.97	1.04	1.06	1.04	0.89	0.83	0.63	0.53	0.33	0.05	0.00	
15.0	454.1	443.1	444.1	443.1	441.1	439.1	436.1	432.1	427.1	421.1	412.1	397.1	380.1	364.1	346.1	326.1	298.1	264.1	196.1	110.1	29.1	1.1	17.59	
12.5	0.42	0.81	0.81	0.80	0.80	0.79	0.78	0.77	0.75	0.91	1.05	0.99	1.08	1.14	1.16	1.14	0.96	0.86	0.66	0.56	0.34	0.00	0.00	
10.0	505.1	494.1	494.1	493.1	490.1	487.1	483.1	478.1	471.1	463.1	451.1	435.1	417.1	394.1	374.1	352.1	323.1	284.1	210.1	113.1	29.1	1.1	16.02	
7.5	0.38	0.75	0.75	0.75	0.74	0.73	0.72	0.71	0.69	0.84	0.96	0.91	0.98	1.03	1.05	1.03	0.87	0.80	0.60	0.50	0.30	0.04	0.00	
5.0	545.1	534.1	535.1	534.1	531.1	524.1	521.1	514.1	506.1	496.1	482.1	462.1	439.1	418.1	396.1	372.1	342.1	300.1	219.1	114.1	29.1	1.1	13.47	
2.5	0.33	0.68	0.68	0.68	0.68	0.68	0.68	0.68	0.68	0.82	0.92	0.87	0.93	0.97	0.99	0.97	0.81	0.74	0.54	0.44	0.24	0.03	0.00	
0.0	579.1	571.1	570.1	569.1	564.1	559.1	552.1	544.1	534.1	523.1	507.1	486.1	461.1	437.1	413.1	388.1	356.1	314.1	224.1	118.1	29.1	1.1	14.38	
0.0	0.35	0.69	0.69	0.69	0.68	0.67	0.66	0.64	0.63	0.76	0.87	0.81	0.87	0.91	0.92	0.91	0.77	0.70	0.50	0.40	0.25	0.03	0.00	
13.0	609.1	602.1	602.1	601.1	599.1	595.1	588.1	581.1	571.1	561.1	547.1	530.1	509.1	480.1	455.1	430.1	403.1	370.1	326.1	231.1	119.1	29.1	1.1	
11.0	0.37	0.72	0.72	0.72	0.72	0.71	0.69	0.67	0.66	0.79	0.90	0.85	0.91	0.95	0.96	0.94	0.80	0.73	0.53	0.43	0.25	0.03	0.00	
9.0	636.1	632.1	630.1	627.1	622.1	615.1	609.1	599.1	584.1	570.1	552.1	527.1	499.1	471.1	444.1	416.1	383.1	335.1	237.1	120.1	29.1	1.1	15.60	
7.0	0.39	0.77	0.77	0.76	0.75	0.74	0.72	0.70	0.68	0.82	0.94	0.88	0.94	0.98	0.99	0.97	0.82	0.76	0.56	0.46	0.25	0.03	0.00	
5.0	688.1	684.1	683.1	682.1	680.1	677.1	672.1	665.1	657.1	647.1	632.1	606.1	585.1	559.1	527.1	497.1	467.1	436.1	400.1	351.1	244.1	121.1	1.1	16.10
3.0	0.41	0.82	0.82	0.81	0.80	0.79	0.77	0.75	0.73	0.88	1.00	0.93	1.00	1.04	1.05	1.03	0.86	0.80	0.60	0.50	0.25	0.03	0.00	
1.0	682.1	680.1	680.1	680.1	682.1	682.1	682.1	689.1	690.1	693.1	697.1	700.1	700.1	700.1	700.1	700.1	700.1	700.1	700.1	700.1	700.1	700.1	700.1	
0.0	0.42	0.85	0.84	0.83	0.82	0.81	0.79	0.77	0.74	0.89	1.02	0.95	1.02	1.06	1.06	1.05	0.87	0.81	0.61	0.51	0.25	0.03	0.00	
-1.0	705.1	704.1	703.1	698.1	690.1	681.1	670.1	657.1	643.1	626.1	604.1	576.1	542.1	510.1	478.1	444.1	407.1	358.1	248.1	121.1	28.1	1.1	17.00	
-3.0	0.43	0.86	0.85	0.85	0.83	0.82	0.80	0.78	0.75	0.91	1.03	0.96	1.03	1.06	1.07	1.04	0.88	0.82	0.62	0.51	0.25	0.03	0.00	
-5.0	712.1	709.1	705.1	700.1	692.1	682.1	670.1	658.1	644.1	627.1	604.1	577.1	543.1	511.1	480.1	448.1	409.1	357.1	243.1	121.1	27.1	1.1	8.52	
-7.0	0.42	0.83	0.83	0.82	0.81	0.80	0.78	0.76	0.74	0.89	1.01	0.94	1.01	1.04	1.04	1.02	0.86	0.80	0.60	0.50	0.25	0.03	0.00	
-9.0	706.1	707.1	704.1	698.1	690.1	681.1	669.1	656.1	642.1	625.1	603.1	576.1	542.1	510.1	479.1	447.1	408.1	357.1	248.1	120.1	27.1	0.1	8.50	
-11.0	0.42	0.83	0.83	0.82	0.81	0.80	0.78	0.76	0.74	0.89	1.01	0.94	1.01	1.04	1.04	1.02	0.86	0.80	0.60	0.50	0.25	0.03	0.00	
-13.0	703.1	702.1	698.1	693.1	685.1	674.1	662.1	649.1	635.1	618.1	595.1	568.1	534.1	502.1	471.1	440.1	401.1	350.1	246.1	118.1	26.1	0.1	16.87	
-15.0	0.43	0.85	0.85	0.84	0.83	0.81	0.79	0.77	0.74	0.90	1.02	0.95	1.02	1.04	1.04	1.02	0.86	0.80	0.60	0.50	0.25	0.03	0.00	
-17.0	690.1	689.1	685.1	680.1	673.1	664.1	653.1	641.1	627.1	611.1	589.1	563.1	529.1	497.1	465.1	437.1	398.1	348.1	243.1	115.1	24.1	0.1	16.59	
-19.0	0.42	0.84	0.83	0.82	0.81	0.80	0.78	0.76	0.73	0.88	1.01	0.94	1.01	1.04	1.04	1.02	0.86	0.80	0.60	0.50	0.25	0.03	0.00	
-21.0	672.1	671.1	668.1	662.1	654.1	647.1	636.1	625.1	612.1	596.1	572.1	545.1	517.1	488.1	458.1	427.1	390.1	342.1	239.1	112.1	23.1	0.1	16.20	
-23.0	0.41	0.82	0.81	0.80	0.79	0.78	0.76	0.74	0.72	0.86	0.98	0.92	0.98	1.02	1.03	1.00	0.84	0.78	0.58	0.48	0.23	0.02	0.00	
-25.0	648.1	650.1	647.1	642.1	634.1	624.1	614.1	605.1	592.1	577.1	558.1	533.1</												

LIGHTING SCIENCES, INC.
 7826 E. EVANS RD.
 SCOTTSDALE, AZ, USA 85260

CERTIFIED TEST REPORT NO. LSI 21628F

YESCO - LED 12.6" X 12.6" DIGITAL SIGN
 RED GREEN BLUE LED ARRAYS AT 20mm SPACING
 OPERATING IN WHITE MODE AT 6800K

INTENSITY (CANDLEPOWER)
 CANDELAS

VERTICAL TRACE				HORIZONTAL TRACE			
ANGLE	CANDLEPOWER	ANGLE	CANDLEPOWER	ANGLE	CANDLEPOWER	ANGLE	CANDLEPOWER
90.0	0.	0.0	710.	90.0	0.	0.0	710.
85.0	0.	-1.0	709.	85.0	4.	-1.0	709.
75.0	0.	-3.0	705.	75.0	66.	-3.0	706.
65.0	0.	-5.0	694.	65.0	174.	-5.0	702.
55.0	2.	-7.0	676.	55.0	317.	-7.0	694.
47.5	3.	-9.0	654.	47.5	390.	-9.0	686.
42.5	3.	-11.0	629.	42.5	431.	-11.0	675.
37.5	6.	-13.0	600.	37.5	464.	-13.0	663.
33.0	17.	-15.0	569.	33.0	496.	-15.0	650.
29.0	50.	-17.0	533.	29.0	527.	-17.0	636.
25.5	78.	-19.5	486.	25.5	562.	-19.5	616.
22.5	106.	-22.5	431.	22.5	591.	-22.5	591.
19.5	200.	-25.5	380.	19.5	616.	-25.5	562.
17.0	332.	-29.0	329.	17.0	636.	-29.0	527.
15.0	463.	-33.0	276.	15.0	650.	-33.0	496.
13.0	546.	-37.5	201.	13.0	663.	-37.5	464.
11.0	595.	-42.5	153.	11.0	675.	-42.5	431.
9.0	627.	-47.5	29.	9.0	686.	-47.5	390.
7.0	652.	-55.0	8.	7.0	694.	-55.0	317.
5.0	675.	-65.0	2.	5.0	702.	-65.0	174.
3.0	692.	-75.0	0.	3.0	706.	-75.0	66.
1.0	705.	-85.0	0.	1.0	709.	-85.0	4.
0.0	710.	-90.0	0.	0.0	710.	-90.0	0.

- UPPER - - LOWER - - RIGHT - - LEFT -

POLAR AXIS HORIZONTAL

Evaluation of Sign Dimming Controller
YESCO 20 mm Prism Sign

Dimmer Setting %	Measured Light Output %
100	100.0
90	91.6
80	82.1
70	72.5
60	62.8
50	52.7
40	42.7
30	32.4
20	22.0
10	11.3

Appendix D

Photometric Data in IESNA Standard Format

IESNA:LM-63-2002
 [TEST] 21628F
 [TESTLAB] LIGHTING SCIENCES, INC.
 [ISSUEDATE] 10/29/2008
 [MANUFAC] YESCO - LED 12.6" X 12.6" DIGITAL SIGN
 [LUMINAIRE] RED GREEN BLUE LED ARRAYS AT 20mm SPACING
 [OTHER] OPERATING IN WHITE MODE AT 6000K
 TILT-NONE

1	5	10	15	20	25	30	35	40	45	50	55	60	65	70	75	80	85	90	95	100	105	110	
1																							
801																							
1																							
37																							
37																							
1																							
1																							
0																							
0																							
1																							
1																							
0																							
0	2.5	5	7.5	10	12.5	15	17.5	20	22.5	25	27.5	30	32.5	35	37.5	40	42.5	45					
47.5	50	52.5	55	57.5	60	62.5	65	67.5	70	72.5	75	77.5	80	82.5	85	87.5	90						
90																							
0	5	10	15	20	25	30	35	40	45	50	55	60	65	70	75	80	85	90	95	100	105	110	
115	120	125	130	135	140	145	150	155	160	165	170	175	180										
	710.2		696.0		674.6		646.4		613.3		566.5		462.7		299.6		174.9		105.6				
	90.5		67.1		38.3		19.1		9.0		6.0		5.1		3.4		2.9		2.7				
	2.5		2.2		1.9		1.5		1.1		0.6		0.3		0.0		0.0		0.0				
	0.0		0.0		0.0		0.0		0.0		0.0		0.0		0.0		0.0		0.0				
	710.2		700.5		682.8		657.1		626.1		585.4		507.8		360.7		220.1		130.1				
	88.0		73.2		50.2		26.7		12.6		7.4		5.6		4.2		3.2		2.8				
	2.7		2.4		2.1		1.7		1.2		0.8		0.4		0.1		0.0		0.0				
	0.0		0.0		0.0		0.0		0.0		0.0		0.0		0.0		0.0		0.0				
	710.2		701.0		683.1		657.7		627.0		586.7		511.2		365.6		223.7		132.6				
	89.1		73.9		52.9		28.2		13.5		7.7		5.7		4.3		3.2		2.9				
	2.7		2.5		2.1		1.7		1.3		0.9		0.5		0.1		0.0		0.0				
	0.0		0.0		0.0		0.0		0.0		0.0		0.0		0.0		0.0		0.0				
	710.2		701.4		683.9		658.9		628.8		590.0		521.3		383.8		239.8		142.9				
	93.0		76.2		57.8		32.2		15.7		8.4		5.9		4.5		3.3		2.9				
	2.7		2.5		2.2		1.8		1.3		1.0		0.5		0.1		0.0		0.0				
	0.0		0.0		0.0		0.0		0.0		0.0		0.0		0.0		0.0		0.0				
	710.2		701.1		683.9		659.5		629.8		592.8		532.0		402.3		257.4		155.8				
	98.8		78.9		63.2		37.5		18.5		9.5		6.2		4.9		3.5		2.9				
	2.8		2.5		2.2		1.8		1.3		1.0		0.5		0.2		0.1		0.0				
	0.0		0.0		0.0		0.0		0.0		0.0		0.0		0.0		0.0		0.0				
	710.2		702.0		685.6		662.2		633.8		598.9		547.1		435.5		289.6		178.2				
	109.7		82.8		69.4		46.2		23.9		12.0		6.9		5.4		4.0		3.1				
	2.8		2.5		2.2		1.9		1.5		1.0		0.5		0.2		0.1		0.0				
	0.0		0.0		0.0		0.0		0.0		0.0		0.0		0.0		0.0		0.0				
	710.2		702.5		686.7		664.1		636.8		604.2		553.3		466.2		326.2		206.8				
	126.2		99.7		74.6		56.4		31.7		16.1		8.4		5.8		4.6		3.3				
	2.8		2.4		2.2		1.9		1.5		1.2		0.6		0.2		0.1		0.0				
	0.0		0.0		0.0		0.0		0.0		0.0		0.0		0.0		0.0		0.0				
	710.2		702.5		687.5		666.0		640.1		609.3		570.8		500.1		376.4		248.9				
	155.2		101.9		79.4		66.8		45.0		23.9		11.9		6.9		5.1		4.0				
	2.9		2.5		2.2		2.0		1.7		1.2		0.9		0.4		0.1		0.0				
	0.0		0.0		0.0		0.0		0.0		0.0		0.0		0.0		0.0		0.0				
	710.2		703.3		688.8		668.8		644.4		615.2		581.5		530.7		433.7		304.5				
	196.9		125.2		87.6		73.7		59.5		36.5		19.0		9.8		6.0		4.7				
	3.5		2.7		2.3		2.0		1.8		1.4		0.9		0.5		0.1		0.0				
	0.0		0.0		0.0		0.0		0.0		0.0		0.0		0.0		0.0		0.0				
	710.2		703.3		689.7		671.0		648.0		620.8		590.5		551.3		486.0		373.8				
	255.6		166.9		109.2		81.7		69.5		54.2		32.7		17.3		8.9		5.6				
	4.3		3.2		2.4		2.2		1.9		1.6		1.1		0.7		0.4		0.1				
	0.0		0.0		0.0		0.0		0.0		0.0		0.0		0.0		0.0		0.0				
	710.2		704.2		691.8		674.5		652.7		627.1		599.0		566.0		522.8		447.5				
	336.0		230.6		152.2		101.8		77.1		66.8		53.0		32.5		17.2		8.9				
	5.4		4.2		3.1		2.3		2.1		1.8		1.4		1.1		0.6		0.2				
	0.0		0.0		0.0		0.0		0.0		0.0		0.0		0.0		0.0		0.0				
	710.2		704.8		693.6		677.7		657.7		633.6		607.2		577.5		544.0		500.4				
	427.4		322.8		223.9		149.9		100.9		76.5		65.4		53.5		35.0		19.4				
	10.1		5.8		4.2		3.2		2.4		2.0		1.8		1.4		1.0		0.5				
	0.2		0.0		0.0		0.0		0.0		0.0		0.0		0.0		0.0		0.0				
	710.2		705.1		695.1		680.7		662.4		640.2		615.5		588.0		558.6		526.8				
	488.0		425.5		332.8		237.1		162.0		110.9		78.8		63.8		54.9		41.4				
	25.3		13.6		7.1		4.6		3.5		2.6		2.2		1.9		1.6		1.1				
	0.6		0.1		0.0		0.0		0.0		0.0		0.0		0.0		0.0		0.0				
	710.2		705.7		696.5		683.4		666.5		646.0		623.2		597.6		570.3		542.2				
	512.0		476.0		429.4		363.4		279.2		198.1		134.5		91.9		67.5		56.0				
	47.7		34.9		21.2		11.4		6.0		4.1		3.2		2.7		2.3		2.0				
	1.4		0.7		0.2		0.0		0.0		0.0		0.0		0.0		0.0		0.0				
	710.2		706.7		698.5		686.5		671.5		652.7		631.8		608.4		582.8		556.4				
	528.2		496.4		465.5		436.5		401.7		349.5		276.5		200.7		135.8		91.5				
	64.3		50.8		42.8		32.6		20.8		11.1		6.1		4.1		3.5		3.0				
	2.7		1.9		0.8		0.2		0.0		0.0		0.0		0.0		0.0		0.0				
	710.2		706.5		699.2		688.2		674.3		657.2		638.2		616.5		592.9		568.4				

541.7	511.0	483.8	460.2	437.5	414.0	389.5	359.0	310.9	246.9
177.9	117.1	74.9	51.1	39.0	30.5	21.5	12.9	7.2	4.6
3.9	3.4	2.3	0.9	0.1	0.0	0.0			
710.2	707.2	700.7	690.8	677.8	661.9	644.1	623.9	602.1	579.3
553.9	524.8	500.7	479.4	458.9	438.5	418.8	399.5	373.9	350.9
327.0	296.8	255.8	202.8	142.6	96.9	48.9	30.2	20.6	14.1
8.4	5.2	3.6	2.2	0.9	0.0	0.0			
710.2	708.2	702.2	693.0	680.8	665.7	648.9	629.8	609.0	587.2
562.1	534.4	512.2	492.9	474.0	455.5	437.9	420.2	396.5	376.8
356.0	331.4	302.9	271.5	237.9	200.2	166.0	135.9	103.0	68.5
37.8	17.8	7.4	3.3	1.1	0.0	0.0			
710.2	706.8	701.5	692.8	681.2	666.7	650.4	632.2	612.4	591.3
567.2	540.2	518.5	499.8	481.8	464.2	448.0	431.3	409.0	390.4
370.0	345.5	316.6	283.8	248.7	209.5	173.7	145.5	120.6	95.1
66.3	43.2	27.2	12.6	3.6	0.5	0.0			
710.2	708.5	703.3	694.7	683.0	668.8	652.2	633.7	613.4	591.8
566.8	539.5	517.3	498.5	479.7	461.5	444.5	427.4	405.0	386.2
365.4	340.9	312.8	280.4	246.2	208.9	174.4	147.7	124.1	99.9
73.6	51.9	35.4	21.2	7.9	0.9	0.0			
710.2	708.5	703.4	694.7	682.6	667.5	650.2	630.8	609.8	587.2
581.8	533.1	509.5	489.1	469.2	450.0	431.4	412.8	389.5	368.3
345.9	321.0	292.9	262.9	232.2	199.6	168.4	143.8	121.8	98.6
74.8	52.8	30.4	9.0	1.5	0.0	0.0			
710.2	708.6	703.2	693.8	681.1	665.2	646.6	625.8	603.1	579.0
552.8	522.6	496.6	474.3	452.7	431.1	410.2	390.0	365.3	341.0
316.4	290.0	262.5	234.5	206.4	178.0	150.5	126.8	102.8	78.2
51.4	17.8	5.6	1.8	0.3	0.0	0.0			
710.2	709.2	703.2	692.8	678.8	661.3	641.2	618.6	594.2	568.5
541.6	510.5	481.1	456.4	432.8	409.0	385.9	363.0	337.7	309.3
282.3	255.2	228.4	202.5	177.6	152.2	121.7	96.4	73.2	51.3
8.8	4.9	2.0	0.5	0.0	0.0	0.0			
710.2	708.8	702.4	690.9	675.4	656.3	634.6	610.3	584.4	557.5
529.5	498.0	465.6	437.9	411.9	385.8	360.0	334.1	308.3	278.1
250.3	223.6	198.1	172.0	140.1	115.9	94.4	51.3	13.4	6.5
4.2	2.1	0.9	0.1	0.0	0.0	0.0			
710.2	708.4	700.8	688.6	671.6	650.7	627.1	600.7	572.8	544.0
514.2	482.5	447.8	416.6	388.0	360.8	333.1	305.6	278.6	249.9
221.1	193.1	159.1	131.6	112.5	82.3	30.9	9.4	5.5	3.8
2.0	1.0	0.2	0.0	0.0	0.0	0.0			
710.2	709.8	700.7	686.4	667.5	644.4	619.0	591.1	561.7	531.2
499.9	467.5	432.3	397.0	365.9	337.2	308.7	280.2	252.8	225.5
190.1	153.5	129.6	109.8	67.6	21.4	7.6	5.2	3.7	2.2
1.2	0.4	0.1	0.0	0.0	0.0	0.0			
710.2	708.2	698.8	683.0	662.3	638.0	611.1	581.0	549.7	517.0
483.2	449.2	414.1	377.2	343.1	313.4	284.8	256.2	227.5	189.5
155.6	131.8	109.4	58.9	17.8	7.4	5.4	3.8	2.5	1.4
0.6	0.2	0.0	0.0	0.0	0.0	0.0			
710.2	707.8	697.6	680.4	658.5	632.6	603.8	571.0	538.0	502.6
486.3	430.5	395.5	360.4	325.0	293.1	264.2	234.1	193.9	161.1
138.9	114.2	58.4	18.8	7.7	5.6	4.2	2.8	1.8	0.9
0.4	0.1	0.0	0.0	0.0	0.0	0.0			
710.2	707.9	696.3	677.4	654.1	626.5	595.7	561.9	525.4	487.4
448.8	411.8	376.5	342.6	309.7	277.2	245.0	202.9	167.9	145.1
121.7	66.0	21.0	9.9	6.2	4.9	3.4	2.2	1.2	0.7
0.1	0.0	0.0	0.0	0.0	0.0	0.0			
710.2	706.6	694.0	674.1	649.2	620.3	587.8	551.7	513.0	473.0
433.2	395.5	360.1	326.5	295.1	263.9	221.5	179.9	154.1	131.8
83.1	29.4	11.1	7.0	5.7	4.2	2.8	1.8	1.1	0.5
0.1	0.0	0.0	0.0	0.0	0.0	0.0			
710.2	706.5	693.2	672.0	645.8	615.3	581.0	542.1	500.9	459.2
418.2	380.2	344.9	311.9	281.2	245.1	200.1	169.9	146.1	107.9
42.5	15.7	8.1	6.6	5.1	3.6	2.4	1.5	0.8	0.4
0.1	0.0	0.0	0.0	0.0	0.0	0.0			
710.2	705.8	691.4	669.0	641.8	610.0	573.9	532.8	499.8	446.8
405.5	367.5	332.5	300.0	268.2	225.0	186.6	161.9	137.1	76.7
75.9	11.3	7.8	6.2	4.7	3.2	2.1	1.3	0.8	0.3
0.1	0.0	0.0	0.0	0.0	0.0	0.0			
710.2	705.1	690.3	667.1	638.9	605.8	567.5	524.7	480.4	436.7
395.2	357.5	322.9	290.9	255.3	210.2	178.4	155.2	119.0	49.4
17.6	9.4	7.4	5.9	4.2	3.0	1.9	1.2	0.7	0.2
0.1	0.0	0.0	0.0	0.0	0.0	0.0			
710.2	704.4	688.6	664.6	635.5	601.2	561.9	517.9	472.2	428.1
386.8	349.2	315.0	283.1	242.8	200.3	172.5	148.6	95.6	34.0
13.6	8.8	7.1	5.7	4.0	2.7	1.8	1.2	0.6	0.2
0.0	0.0	0.0	0.0	0.0	0.0	0.0			
710.2	704.1	688.0	663.4	633.9	598.5	556.0	513.4	467.3	422.8
381.2	343.9	310.0	277.5	234.1	195.1	169.2	142.5	78.0	27.1
11.9	8.3	7.1	5.5	3.9	2.6	1.8	1.2	0.6	0.1
0.0	0.0	0.0	0.0	0.0	0.0	0.0			
710.2	702.6	686.0	661.2	631.0	595.1	554.1	508.6	461.7	417.2
376.0	339.1	306.0	272.7	228.3	192.1	167.4	137.0	67.4	23.7
11.0	8.1	6.9	5.3	3.7	2.5	1.7	1.0	0.5	0.1
0.0	0.0	0.0	0.0	0.0	0.0	0.0			
710.2	707.7	694.3	671.2	642.5	608.4	568.7	524.1	476.8	430.9
387.9	349.6	315.3	284.1	242.8	200.8	174.7	152.7	87.6	29.1
12.6	8.7	7.5	6.0	4.2	2.9	1.9	1.3	0.8	0.3
0.0	0.0	0.0	0.0	0.0	0.0	0.0			

Appendix E

Recalculated versions of Table 2 for other sign sizes. Note: These values are not part of the proposed sign luminance specification procedure. See also section 10 of report.

Table 2a		
150 sq. ft. Sign at a Distance of 100 Feet		
Sign Luminance Limits		
Zone	Eye Illuminance Limit (fc) per IESNA	Sign Luminance (Nits)
LZ1	0.1	48
LZ2	0.3	144
LZ3	0.8	383
LZ4	1.5	718

Table 2b		
200 sq. ft. Sign at a Distance of 100 Feet		
Sign Luminance Limits		
Zone	Eye Illuminance Limit (fc) per IESNA	Sign Luminance (Nits)
LZ1	0.1	27
LZ2	0.3	81
LZ3	0.8	215
LZ4	1.5	404

Table 2c		
250 sq. ft. Sign at a Distance of 100 Feet		
Sign Luminance Limits		
Zone	Eye Illuminance Limit (fc) per IESNA	Sign Luminance (Nits)
LZ1	0.1	17
LZ2	0.3	52
LZ3	0.8	138
LZ4	1.5	258

Table 2d		
300 sq. ft. Sign at a Distance of 100 Feet		
Sign Luminance Limits		
Zone	Eye Illuminance Limit (fc) per IESNA	Sign Luminance (Nits)
LZ1	0.1	12
LZ2	0.3	36
LZ3	0.8	96
LZ4	1.5	179

Table 2e		
400 sq. ft. Sign at a Distance of 100 Feet		
Sign Luminance Limits		
Zone	Eye Illuminance Limit (fc) per IESNA	Sign Luminance (Nits)
LZ1	0.1	7
LZ2	0.3	20
LZ3	0.8	54
LZ4	1.5	101

Positive Code Language

Brownwood, TX (Passed Sept 2008)

Sec. 90-176. Electronic Message Sign.

- (1) Electronic message signs shall be allowed subject to all the regulatory provisions contained herein governing signs and billboards in general, in addition to the specific provisions contained in this section. An electronic message sign, depending on what type of sign it is, i.e, freestanding, hanging, wall, portable or other type of sign, must meet all requirements applicable for that sign. Should any provisions be in conflict, the more stringent provision shall control.
- (2) Electronic message signs shall have the following operational limitations:
 - (a) The display of a static message or image and the use of scroll/travel to display a message or image shall be permitted on all electronic message signs.
 - (b) The use of flashing and moving video shall be prohibited on all electronic message signs.
 - (c) The use of animation shall be prohibited on electronic message signs/large.
 - (d) The use of any other type of transition, such as dissolve/fade and frame effects, shall be prohibited on electronic message signs/large except in accordance with the following:
 - (i) Each message or image must be displayed for a minimum of three seconds; and
 - (ii) The change of message or image must be accomplished within two seconds or less and must occur simultaneously on the entire sign face.
 - (e) The use of animation and other types of transition, such as dissolve/fade and frame effects shall be permitted on electronic message signs/small.
 - (f) An electronic message sign must be equipped with both a dimmer control or other such electronic control and a photocell or other such automatic control, which will produce the required illumination change according to natural ambient conditions as provided in Section 90-136(c)(iii).

Wichita, KS (Passed August 2007)

Sec. 24.04.185. Classifications and Definitions.

- j. Sign, Electronic Message. A variable message sign that utilizes computer-generated messages or some other electronic means of changing copy. These signs include displays using incandescent lamps, LEDs, LCDs or a flipper matrix, and may also enable changes to be made to messages from locations other than at the sign. Electronic message signs shall be classified as animated, flashing or moving signs when the rate of copy and/or graphic changes is more than one change per second;

Sec. 24.04.220. General requirements.

- (q) Electronic Message Signs. No electronic message sign shall be erected or installed without dimming controls to ensure the sign is appropriately dimmed at night. Acceptable dimming controls include automated light sensing devices (photocells) and/or programmable controls that are set by the user to automatically dim the sign at night. Generally, the maximum nighttime brightness and/or light intensity shall not exceed 3,000 nits (or equivalent). For electronic message signs that have a maximum

brightness and/or light intensity of 3,000 nits or less (or equivalent), dimming controls shall not be required.

- (r) Flashing or Moving Signs. No flashing signs, rotating or moving signs, animated signs, signs with moving lights, or signs which create the illusion of movement shall be permitted in a residential zoning district, or in the "NO" Neighborhood Office district, "GO" General Office district, "NR" Neighborhood Retail district, "OW" Office/Warehouse district, or the "IP" Industrial Park district.

Oklahoma City, OK (Currently within the regulatory process)

§3-82. Definitions

- (16.1) **Electronic Message Display** means a sign capable of displaying words, symbols, figures or images that can be electronically or mechanically changed by remote or automatic means. These signs are further defined into the following categories:

Level 1: (Static and /or Static with Fade and/or Dissolve Transitions) Electronic Message Display - an electronic message display complying with the following standards:

Operational Limitations. Such displays shall contain static messages, changed through dissolve or fade transitions, or with the use of other subtle transitions and frame effects that do not have the appearance of moving text or images, but which shall otherwise not have movement, or the appearance or optical illusion of movement, of any part of the sign structure, design, or pictorial segment of the sign, including the movement of any illumination or the flashing or varying of light intensity. Minimum Display Time: Each message on the sign must be displayed for a minimum of eight seconds.

Level 2: (Travel/Scroll Transitions and without Animations) Electronic Message Display - an electronic message display complying with the following standards:

Operational Limitations. Such displays shall be limited to static displays, messages that appear or disappear from the display through dissolve, fade, travel or scroll modes, or similar transitions and frame effects that have text, graphics or images that appear to move or change in size, or be revealed sequentially rather than all at once.

Level 3: (Video/Animation) Electronic Message Display - A sign capable of displaying words, symbols, figures or images that can be electronically or mechanically changed by remote or automatic means, including animated graphics and video.

- a. Operational Limitations. Such displays may include any level 1-2 type displays, as well as animated graphics and full motion video.
- b. Display time. There shall be no minimum or maximum message duration.

§ 3-102. Accessory signs regulated by zoning districts

- (c) **Standards for commercial and industrial zoning districts (other than O-1, O-2, and C-1).**

- (7) Electronic Message Displays. Electronic Message Displays (EMD) shall be allowed subject to the limitations as follows:
 - a. Level 1 EMD shall be permitted subject to the same regulations as static display signs listed in this section.
 - b. Level 2 EMD shall be permitted up to 350 square feet of the total allowable sign area.
 - c. Level 3 EMD shall be permitted up to 350 square feet of the total allowable sign area.

Chicago, IL

17-17-0234 Changing-image Sign. Any *sign* that, through the use of moving structural elements, sequential lights, lighting elements, or other automated method, results in movement, the appearance of movement or change of *sign* image or message. *Changing-image signs* do not include otherwise static *signs* where illumination is turned off and back on not more than once every 24 hours.

17-17-0256 Flashing Sign. Any *sign* or portion of a *sign* that contains an intermittent or flashing light source or that changes light intensity in sudden transitory bursts. Example of *flashing signs* include *signs* that contain or use strobe lights, or rotating lights; *signs* with blinking or flashing features that are designed to merely to attract attention rather than convey a message; and *changing-image signs* that do not comply with applicable standards.

17-12-1005 Additional Standards for Specific Types of Signs

B. Changing-image Signs

In B1 and B2 districts, *sign* face area devoted to *changing-image signs* may not exceed 25% of the maximum total *sign* area allowed under Sec. 17-12-1003 or 100 square feet. In all districts, *sign* face area devoted to *changing-image signs* may not exceed 25% of the maximum total *sign* area allowed under Sec. 17-12-1003 or 200 square feet.

C. Flashing Signs

1. Maximum Area

The total *sign* face area of all *flashing signs* on a *lot* may not exceed 25% of overall *sign* area limit or 100 square feet, whichever is less.

2. Maximum Height

No part of any *flashing sign* may exceed a height of 24 feet.

3. Prohibited Locations

Flashing signs are prohibited in the following locations:

- (a) B1 districts;
- (b) B2 districts;
- (c) Within 125 feet of any R or public park with an area of 2 acres or more;
- (d) Within 100 feet of any DR district;
- (e) Within 500 feet of Lake Shore Drive;
- (f) Within 500 feet of any expressways or toll roads, as designated by the Chicago Department of Transportation; and
- (g) Within 500 feet of Michigan Avenue, between Oak Street on the north and Roosevelt Road on the south.

Sioux Falls, SD (Passed in 2007)

Sioux Falls allows almost any usage other than flashing. However, in residential areas EMCs require a conditional use permit.

On-Premise 15.57.070 Illumination.

Regulations regarding the illumination of signs shall be as follows:

- (a) *Shading:* The light from any illuminated sign shall be so shielded, shaded or directed so that the light intensity shall not adversely affect surrounding or facing premises or safe vision of operators of vehicles on public or private roads.

- (b) *Electronic message sign:*
 - (1) Electronic message sign displays shall be limited to displays, which are gradual movements, including, but not limited to, dissolve, fade, scrolling, or traveling. However, sudden movement is prohibited, including, but not limited to, blinking and flashing.
 - (2) All electronic message signs in a residential zoning district shall require a conditional use permit.
 - (3) Any permitted signs may be, or may include as an individual component of the total sign area, electronic message signs.
Electronic messages or graphic displays may be changed at periodic intervals by gradual entry and exit display modes provided that messages and animation shall be displayed at periodic intervals by various modes, such as fade, dissolve, scrolling, or traveling.

Off-Premise 15.58.020 General regulations.

- (j) Blinking or flashing lights are prohibited. Electronic message signs are permitted.

Abilene, TX (Passed November 2008)

23-128 Definitions

- (7) Electronic Message Sign. A sign whose informational content can be changed or altered on a fixed display screen composed of electrically illuminated segments, including LED (light emitting diode) signs, television screens, plasma screens, video boards, or other digital signs.

23-172 Special Regulations for Electronic Message Signs

In addition to any other requirements of this Chapter, Electronic Message Signs shall adhere to the following requirements:

- (A) Operational limitations for on-premise signs over 75 square feet in area or any off-premise sign.
 - 1. Such signs shall contain static messages only and shall not have movement, or the appearance or optical illusion of movement, of any part of the sign or sign structure, including the movement or appearance of movement of any illumination or the flashing, scintillating, or varying of light intensity.
 - 2. Minimum display time. Each message on the sign must be displayed for a minimum of eight seconds.
 - 3. Transition. The transition from one sign message to another must occur within two seconds and may not include flashing or appearance of motion, with the exception of a fade out or in, dissolve, or scroll that must be accomplished within the transition period.
- (B) Operational Limitations for all signs.
 - 1. Limitations. All such signs shall have no flashing or full motion video.
 - 2. Unless permitted as an off-premise sign, such signs shall not include off-premise advertising messages.
- (C) Sign face limitations.
 - 1. Each sign structure is limited to not more than two sides with one sign face per side.

2. The entire sign face must comply with the operation limitations defined above and a sign face may not be apportioned into separate areas each acting as a separate sign face under these restrictions.
- (D) Brightness.
1. All such signs shall be equipped with light sensing devices or a scheduled dimming timer that will automatically dim the intensity of the light emitted by the sign during ambient low-light conditions and at night so that the sign does not exceed the maximum brightness levels allowed in this section.
 2. Maximum brightness shall not exceed 7,000 nits when measured from the sign's face at its maximum brightness during daylight hours and shall not exceed 1,000 nits when measured from the sign's face at its maximum brightness at night.
 3. If such sign is located within 100 feet of a property with residential zoning, the sign must be oriented such that no portion of the electronic sign face is visible from a residentially-zoned property or the brightness is reduced to no more than 250 nits at night.
 4. Prior to the issuance of a permit for such sign, the applicant shall provide written certification from the sign manufacturer that the light intensity has been factory pre-set not to exceed the levels specified above.
- (E) The City may order a sign's brightness reduced, its minimum display time increased, or other operational characteristics altered if the Director of Public Works, or designee, finds that it interferes with or poses a traffic safety hazard to the operation of vehicles.
- (F) All such signs shall be turned off or display a blank screen when malfunctioning.

Bemidji MN (Passed Oct 2008)

B. Regulations. Dynamic displays on signs, where specifically allowed by permit in various zoning districts, shall comply with the following regulations:

1. **Brightness.** LED dynamic displays shall have a maximum of twenty (20%) percent night time brightness setting and may operate at up to a one hundred (100%) percent day time brightness setting. Incandescent dynamic displays shall have a maximum of sixty (60%) night time brightness and may operate at up to a one hundred (100%) day time brightness setting. Constant night time displays of bright or "hot colors" such as complete red or white display background shall be prohibited. All dynamic displays shall be equipped with a night time manufacturer auto dim feature and operated according to manufacturer night time intensity specifications.
2. **Time/duration.** Full dynamic display animation electronic programming without any minimum frame hold display time duration may be allowed for all display changes during day time dynamic sign programming. All dynamic displays, including both new and legal non-conforming displays, shall comply with the minimum night time electronic frame hold display time duration for all display changes. The night time minimum frame hold display time duration **shall not be less than three (3) seconds.**

3. **Method of dynamic displays.** During the night time electronic dynamic sign programming there will be no restriction on the method or type of display frame hold time transitions, except that there shall be no animation, motion, blinking, scrolling, rotating, oscillating, etc during the dynamic display minimum frame hold display time duration.
4. **Night time programming.** Dynamic display owners and operators shall be required to maintain the minimum electronic frame hold display time duration during the night time display mode for both brightness and dynamic displays for all electronic dynamic signs. Legal non-conforming signs without a manufacturer auto dim feature shall comply with this requirement to the extent feasible within the limits of the dynamic display programming.
5. **Percentage of sign area.** Dynamic displays may be permitted on freestanding pylon and monument signs or as a wall sign. Dynamic displays may occupy no more than 45% of the allowable sign area of the total freestanding pylon, monument or wall sign area for a building or single tenant in a multi-tenant center.
6. **Maximum number.** There shall be no more than one dynamic sign permitted per property for freestanding signs, except as may be permitted for additional signage along one-way pairs. Where a dynamic display is requested to be mounted as part of the building wall signage, there shall be no more than one dynamic display permitted per wall elevation and the maximum number of wall elevations per building shall be two (2), including multi-tenant centers. Dynamic displays which are mounted in a back-to-back configuration shall count as one (1) dynamic display, provided the total angle for mounting does not exceed sixty (60) degrees.
7. **Spacing from residential uses.** No electronic dynamic display shall be located within one hundred (100') feet of a residential district. The distance shall be measured based upon a horizontal line beginning at the nearest residential property line and the leading edge of the dynamic display, or a viewing radius of forty five (45) degrees, whichever is closer.
8. **Spacing from traffic control signals.** No dynamic display shall be located within fifty (50') feet of an official traffic control signal. The distance shall be measured based upon a horizontal line beginning at the leading edge of the dynamic display and any portion of the traffic control device.

Bismarck, ND (Passed February 2009)

4-04-11. Special Provisions for Electronic Message Center Signs. In addition to other applicable provisions contained in this Chapter, the following provisions shall apply to the placement and operation of electronic message center signs:

1. Electronic message center signs may only be used as permanent on premise signs. Electronic message center signs shall not be used as temporary signs or as off premise signs. Electronic message center signs may be used for demonstration purposes

- provided the sign is used on the site for 24 hours or less, the sign is used as an on-premise advertising sign without any off-premise advertising and the sign is located outside of any sight triangle.
2. Electronic message center signs may only be located on pole (pylon) signs and wall signs. Electronic message center signs shall not be located on fin signs, ground signs (billboards), projecting signs, or roof signs, or used as portable signs.
 3. Electronic message center signs are permitted only in the MA-Industrial, CG-Commercial, CA-Commercial, DC-Downtown Core, DF-Downtown Fringe, RT-Residential, HM-Health Medical and P-Public zoning districts.
 4. No electronic message center sign installed after (the effective date of this ordinance) shall be permitted to operate unless it is equipped with:
 - a. A default mechanism that shall freeze the sign in one position as a static message if a malfunction occurs; and
 - b. A mechanism able to automatically adjust the illuminative brightness of the display according to ambient light conditions by means of a light detector/photocell. An electronic message center sign installed prior to (the effective date of this ordinance) shall be allowed to continue operation provided the brightness of the sign does not exceed a maximum illumination of five thousand (5,000) NITS during daylight hours or a maximum illumination of seven hundred and fifty (750) NITS between one-half hour before sunset to one-half hour after sunrise as measured at the sign's face at maximum brightness.
 5. Only one (1) electronic message center sign shall be allowed per property. An electronic message center sign with two (2) faces back-to-back shall be treated as one (1) sign, provided said faces are parallel or have an angle of separation of no more than thirty (30) degrees. Two (2) or more electronic message center signs mounted side-by-side shall not be treated as one sign and shall not be allowed.
 6. The electronic message center sign portion of any sign shall not exceed the area specified in the table below, (which is based on the zoning district in which the sign is located and the functional classification of the roadway adjacent to the sign), or fifty (50) percent of the total sign area, whichever is greater.
 7. The electronic message center sign portion of a pole (pylon) sign shall not exceed forty (40) feet in height in a MA-Industrial or CG-Commercial zoning district or exceed twenty-five (25) feet in height in a CA-Commercial, DC-Downtown Core, DF-Downtown Fringe, HM-Health Medical, RT-Residential or P-Public zoning district, measured from the top of the nearest curbline to the top of the sign or structure. The electronic message center sign portion of a pylon sign shall be located no less than ten (10) feet above the adjacent street grade.
 8. No portion of any sign containing an electronic message center shall project over the public right-of-way or any property line or be located within the sight triangle of intersecting streets.
 9. Electronic message center signs shall be subject to the following operational requirements:
 - a. The sign shall have a frame hold time of no less than one (1) second. The use of animation and background animation is allowed and is not subject to the one (1) second frame hold time requirement.

- b. Entrance and exit effects may be used to transition from one frame to another, provided said entrance effects result in all of the text within the frame appearing at once or in the order that the text is normally read (including, but not limited to, scrolling from right to left or scrolling from bottom to top entrance effects). Entrance effects where all of the text within the frame does not appear at once or in the order that the text is normally read are prohibited (including, but not limited to, scrolling from left to right, scrolling from top to bottom, and entrance effects referred to as slot machine, slots, splice, mesh, radar, kaleidoscope and spin). There are no limitations on the types of exit effects used. Except for such transitions, each frame shall remain static with no additional frame or hold effects applied to text within the frame (including, but not limited to, the fading or flashing on any part of the message and hold effects referred to as flash, spin, twinkle, wavy and rumble). The use of bijou lights as a frame effect is allowed.
 - c. The use of streaming video, or fullmotion video on any electronic message center sign is prohibited.
 - d. The use of the words “stop”, “danger” or “caution” as the only text within a frame is prohibited.
- 10. Electronic message center signs located within one hundred fifty (150) feet of any RRResidential, RR5-Residential, R5-Residential, R10-Residential, RM-Residential or RMH-Residential zoning district, as measured from any part of the sign to the nearest property line within any residential zoning district, are subject to the following additional requirements:
 - a. The sign shall not exceed thirty-two (32) square feet in area, or fifty (50) percent of the total sign area, whichever is greater.
 - b. Between 8:00 7:00 a.m. and 10:00 p.m., the sign shall be allowed to operate in accordance with the provisions of Section 4-04-11(9) of this Chapter. Between 10:00 p.m. and 8:00 7:00 a.m., the sign shall only display static images with a frame hold time of no less than three (3) second and shall be limited to instantaneous transitions from one static frame to another static frame without the use of any frame entrance, exit or hold effects or the use of any animation or background animation.
- 11. An electronic message center sign cannot be installed on an existing sign that is nonconforming unless the entire sign is brought into compliance with all applicable provisions of this Chapter.
- 12. No portion of any existing sign shall be replaced with an electronic message center sign unless a sign permit is obtained for the new electronic message center sign.

Missoula, MT (Currently within the regulatory process)

F. Dynamic Displays Electronic Graphic Display Signs

Dynamic displays on signs are allowed subject to the following regulations:

1. **Where Allowed**
Dynamic displays are permitted for public and civic uses in R and OP districts and for all allowed uses in other districts.
2. **Maximum Dynamic Display Area**

The dynamic display portion of the sign may not exceed 40 square feet or 50% of the total area of the sign, whichever is less, and must be computed as part of the sign's total area. The remainder of the sign may not have the capability to have dynamic displays even if not used. Only one, contiguous dynamic display area is allowed on a sign face.

3. Spacing

Electronic graphic display signs are prohibited within 100 feet of any lot occupied by a residential building.

4. Orientation

The sign face must be oriented away from residential uses and adjacent residential zoning districts.

5. Hold Time

Dynamic displays are subject to the following minimum hold times, meaning the display or message may not change or move more often than the stated minimum hold time:

Zoning Districts	Minimum Hold Time (seconds)
R and OP	60
B, CBD, C1, and M1R	1
C2, M1, and M2	None

6. Transitions

a. R and OP Districts

In R and OP zoning districts the images and messages displayed must be complete in themselves, without continuation in content to the next image or message or to any other sign. The images and messages displayed must be static, and the transition from one static display to another (after the minimum hold time) must be instantaneous without any special effects.

b. Other Districts

In districts other than R and OP zoning districts the transition from one image to the next must be accomplished in one second or less. Fading, scaling, scrolling, and dissolving effects may be used as part of the transition.

7. Message Duration

Each complete message on a dynamic display must be completed within the following limits:

Zoning Districts	Message Duration (seconds)
R and OP	60
B, CBD, C1, and M1R	same as "hold time"
C2, M1, and M2	No less than 5; no more than 8

8. Minimum Copy and Graphic Size

Every line of copy and graphics in a dynamic display must be at least 7 inches in height on a road with a speed limit of 25 to 34 miles per hour, 9 inches in height on a road with a speed limit of 35 to 44 miles per hour, 12 inches in height on a road with a speed limit of 45 to 54 miles per hour, and 15 in height inches on a road with a speed limit of 55 miles per hour or more. If there is insufficient room for copy and graphics of this size in the maximum dynamic display area allowed under these regulations, then no dynamic display is allowed.

9. Display Malfunctions

The sign owner must immediately stop the dynamic display when notified by the city that it is malfunctioning or otherwise not complying with the standards of this zoning ordinance.

10. Brightness

Dynamic displays may not exceed a maximum illumination of 5,000 nits (candelas per square meter) during daylight hours or more than 500 nits during nighttime hours (between dusk and dawn), as measured from the sign's face at maximum brightness. Dynamic displays must be equipped with automatic dimming technology that automatically adjusts the display's brightness based on ambient light conditions.

11. Prohibited Display Types

Dynamic displays may not use blinking, bursting, distorting, flashing, oscillating, rotating, shimmering, sparkling, streaming, tracing or twinkling effects. Audio or pyrotechnic elements are also prohibited.

12. Nonconformities

Dynamic displays existing on [insert effective date] must comply with all the operational standards of this subsection. An existing dynamic display that does not meet the structural requirements of 20.75.070F.2 may continue as a nonconforming sign subject to the nonconforming sign regulations of 20.75.120. An existing dynamic display that cannot meet the minimum size requirement 20.75.070F.8 must use the largest size possible for one line of copy to fit in the available space.