USSC FOUNDATION

On-Premise Sign Standards

Research-based Approach to:

- Sign Size
- Sign Legibility
- Sign Height
- Parallel Sign Size
- Sign Lighting

USSCF ON-PREMISE SIGNS / BEST PRACTICES STANDARDS

USSC Foundation
Best Practice Standards for On-Premise Signs

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A Research Based Approach To:
Sign Size
Sign Legibility
Sign Height
Parallel Sign Size
Sign Lighting

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PREFACE, The Advancement of Scientific Research

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

Since 1996, the United States Sign Council Foundation, in concert with traffic engineers, human factors researchers, and statistical analysts of the Pennsylvania Transportation Institute of the Pennsylvania State University, has published a series of research studies. The results from this work now provide a distinct and objective scientific basis for understanding the manner in which motorists receive and respond to the information content of the private, roadside sign system. The research and corresponding analyses afford designers and regulators of signs with an insight into the legibility, size, and placement characteristics necessary for effective roadside communication to occur. Coincidental with the work of the Pennsylvania State University research teams, other researchers, including teams studying the impact of sign systems serving the needs of an aging population on traffic safety, have arrived at conclusions essentially confirming the sign legibility and placement parameters discovered by the Pennsylvania State University researchers.

Ten distinct volumes comprise the United States Sign Council / Pennsylvania Transportation Institute collaborative research work:

1) SIGN VISIBILITY, Research and Traffic Safety Overview (1996)
2) SIGN LEGIBILITY, The Impact of Color and Illumination on Typical On-Premise Sign Font Legibility (1998)
3) REAL WORLD ON-PREMISE SIGN VISIBILITY, The Impact of the Driving Task on Sign Detection and Legibility (2002)
4) SIGN VISIBILITY, Effects of Traffic Characteristics and Mounting Height (2003)
5) ENVIRONMENTAL IMPACT OF ON-PREMISE SIGN LIGHTING, With Respect to Potential Light Trespass, Sky Glow, and Glare (2004)
6) RELATIVE VISIBILITY OF INTERNALLY AND EXTERNALLY ILLUMINATED ON-PREMISE SIGNS (2004)
7) ON PREMISE SIGNS, Determination of Parallel Sign Legibility and Letter Heights (2006)
8) INTERNALLY ILLUMINATED SIGN LIGHTING, Effects on Visibility and Traffic Safety (2009)
9) INTERNAL vs. EXTERNAL ON-PREMISE SIGN LIGHTING, Visibility and Safety in the Real World (2009)
10) ON-PREMISE SIGN LIGHTING, Terms, Definitions, Measurement (2010)

Together, these volumes, along with the aforementioned corroborating research provided by other teams, comprise the basis for the United States Sign Council Best Practices Standards for the design of roadside on-premise signs in dynamic motorist-oriented environments.

OVERVIEW, Seeing and Reading Roadside On-Premise Signs

The viewing of a roadside sign by a motorist involves a complex series of sequentially occurring events, both mental and physical. They can include message acquisition and processing, intervals of eye movement alternating between the sign and the road environment and, finally, active maneuvering of the vehicle itself as required in response to the stimulus provided by the sign.

Further complicating this process, is the dynamic of the viewing task itself. The subject must look through the constricted view frame of the windshield of a moving vehicle, with the distance between him/herself and the sign quickly diminishing. At 40 miles per hour, for example, the rate at which the viewing distance decreases is 58 feet per second; at 50 miles per hour, it becomes an impressive 88 feet per second. Because of this rapidly decreasing window of viewing opportunity, roadside sign design becomes highly challenging and critical to traffic safety. In addition, it necessitates the development of scientific standards for on-premise sign legibility, size, placement, and height in order to achieve effective roadside communication and maintain traffic safety.

Research has now been able to quantify the viewing process, such that measurement of the time necessary for a motorist to view and react to a roadside sign, while driving at a specified rate of speed, can be calculated. Using this time frame, or Viewer Reaction Time, and the amount of distance from the sign represented by that time frame, the optimal sign size required to transmit the message and allow sufficient time for detection, comprehension, and maneuvering can be calculated reliably.

The message content of the sign, usually composed of letterforms and/or symbols, sets the initial parameter for determining sign size. Once message content has been established and its length and/or complexity considered, sign size can be ascertained by assigning numerical values to the following:

1) Viewer Reaction Time
2) Viewer Reaction Distance
3) Letter Height

4) Copy Area
5) Negative Space

Each of these determinants is explained in detail below, along with the methodology for calculating their individual values. The size of the sign, then, can be computed either by summing these five determining values or by inserting them into the algebraic equation developed by USSC for that purpose. The result derived by using either method is the USSC standard for minimum sign size under dynamic roadside conditions.

DETERMINING SIGN SIZE – The Component Determinants

Viewer Reaction Time
The Viewing/Reaction Process

Viewer Reaction Time is a measurement of the total viewing and reaction time available to a driver reading a sign. It consists of four identifiable elements, each of which can be measured in components of elapsed time. They are:

1) Detection of the sign, noting it as a separate entity in a field of roadside objects;
2) The Message Scan, or fixation of view on the message contained on the sign;
3) The Re-Orientation Scan, or refocus of view from the message to the road environment at known intervals;
4) Driving Maneuvers as required in response to the message.

Detection

Detection of a specific sign as a recognizable element of the roadside landscape is a direct function of its *conspicuity*, or its ability to stand out from other objects within the field of view. The degree of conspicuity depends on a number of factors, including size, color, design, and placement, but even more specifically, the amount of contrast between the sign and its surrounding environment. Without some degree of conspicuity, a sign may lack detectability and cease to be a source of effective roadside identity or wayfinding communication.

Detection and Complexity of Driver and Sign Environment

Research has shown that detection is inversely related to the complexity of both the driving task and the landscape. Thus, as complexity increases for either or both the driving task and the visual environment, detection of any specific object within that landscape is likely to decrease. The more complex the landscape (e.g., city centers or multi-lane commercial corridors), the longer the time frame in the viewing cycle necessary and, therefore, the more conspicuous signs need to be for specific detection.

In this context, the effect of illumination can also have a profound effect on detectability, with the research verifying a pronounced increase in detection after dark for internally illuminated signs over similar signs viewed under daylight conditions.

Detection and Sign Orientation

Detectability is also a function of sign orientation, or the relative angle of view between the sign and the viewer. This angle has been shown to be at an optimum level when signs are positioned perpendicular to the viewer, and at initial detection, within a cone of vision extending 10 degrees to either side of the viewer. As confirmed by the research, “head-on”, or perpendicular views, are far superior in detectability to parallel or side oriented views.

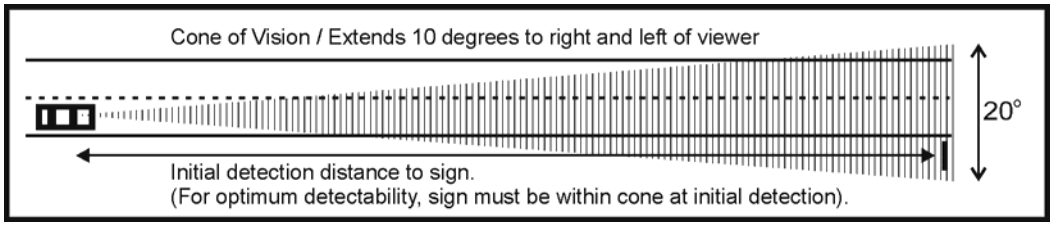


Figure 1. Cone of Vision and Detectability

Lateral Offset or Setback and The Cone of Vision

Lateral Offset, or Setback is the distance in feet at which the sign is offset to the right or left of the driver's eye position. It is critical to detectability because it determines the position of the sign either inside or outside the cone of vision at initial detection.

To assure optimal initial detection within the cone of vision, the sign should be located as close to the roadside as possible, so that the lateral offset is kept to a minimum. This usually means placement of the leading edge of a freestanding sign at the front property line, and signs on the sides of buildings as close to the front of the building as is practical. Arbitrarily imposed setback requirements increasing lateral offset beyond these parameters are generally counter productive to sign detection since they increase the distance of the sign from the driver's eye position, even if it is within the cone of vision.

It is important to note, as well, that roadside geometry affects any lateral offset calculation, which must include the number of road lanes, the width of the shoulder, and, in particular, the width of any utility or future right of way easements before the property line is reached; all of which add considerable lateral distance from the driver's eye position. In some instances in which public easements are large and initial detection distances are short, lateral offset may exceed the cone of vision inclusion even if the sign is placed at the property line.

Increasing sign size, and therefore, visual range, is one solution to this detection problem, since as visual range increases, lateral offset is also increased.

Lateral offset from the viewer's eye position can be calculated through the application of the following equation in which:
L equals ten degrees of lateral offset.
D equals distance in feet from the sign at initial detection.

$$L = D\,(.176)$$

Thus, if initial detection distance from the sign is 300 feet, 10 degrees of lateral offset would be 52 feet. Note that this offset is from the driver's eye position, and not from some variable point, such as the edge of the road, road shoulder, or roadside easement.

Vertical Offset or Sign Height

Sign height limits which would enable sign detection without loss of eye contact with the road have variously been recommended by researchers at between five to eight degrees vertically from the driver's eye level. Researchers at the Pennsylvania Transportation Institute have adopted the five degree vertical limit as a conservative estimate of sign height limits, or vertical offset. Since additional research into this aspect of sign detection clearly remains to be done, particularly since sign height is affected not only by the viewer's eye position, but by differences in the topography of the roadside itself, the five degree height limit proposed by the PTI research team is offered here only as a minimum guideline for the vertical placement of roadside signs, and not as a USSC standard at this time.

Nonetheless, it can serve to provide some means for optimizing the relationship between sign height, sign detection over both long and short ranges, and motorist safety. Using five degrees of vertical elevation, plus 3.5 feet representing elevation of the average driver's eye position above the road, a calculation of vertical sign height limits capable of providing comfortable detection over both long and short ranges can be derived from the following equation in which:

H equals sign height limit.
D equals distance in feet from the sign at initial detection.

$$H = D\ (.088) + 3.5$$

Thus, if initial detection distance from the sign is 400 feet, the sign height would be limited to 38.5 feet.

Table 1 below indicates varied Lateral and Vertical Offsets for selected detection ranges.

Detection Distance To Sign	Lateral Offset (Setback)	Vertical Offset (Height Limit)
200 ft.	35 ft.	21 ft.
400 ft.	70 ft.	38.5 ft.
600 ft.	106 ft.	55.5 ft.
800 ft.	141 ft.	73.5 ft.
1000 ft.	176 ft.	90.5 ft.

Lateral Offset at 10 degrees right or left.

Vertical Offset at 5 degrees plus 3.5 feet.

Table 1. Lateral and Vertical Offsets as function of distance.

Detection…Conclusion

The USSC Best Practices Standards for sign legibility and size assumes that conditions of sign orientation and setback afford optimum detectability, as described above. In practice, these conditions would include most freestanding and projecting signs, building signs on walls directly facing the viewer, and roof signs mounted at similar optimum viewing angles within the cone of vision.

Detection as a component of Viewer Reaction Time in the USSC standard is calculated at one-half to one second duration, depending on roadside complexity and traffic volume.

The Message Scan / The Re-Orientation Scan

The message depicted on a sign establishes the time frame for the essential component of the viewing process. Short messages and/or simple typography take less time to read and mentally process than long messages and/or cursive or decorative typography.

In this context, it should be noted that on-premise signs frequently contain a variety of messages, which may be displayed in a number of different sizes and font configurations. The USSC standard for sign size is related principally to Primary Messages, or those messages providing essential information relative to the activities conducted on the site (e.g., the name of the activity, the nature of the activity or product available, principal or major occupants of the site, and other information of similar nature). Secondary Messages are usually designed to provide ancillary information concerning product features or to denote secondary occupants of the site, as seen on site directories. While clearly useful to roadside viewers and to the marketing programs of the sign user, secondary messages are considered less important to the immediate transfer of information demanded of signs placed in a high-speed, dynamic roadside environment in which viewing and reaction time is calculated in seconds.

Current research on average reading times indicates that signs displaying four to eight words in simple typography can be comfortably read and comprehended in approximately four seconds, yielding a reading time, or Message Scan, of one-half second per word. Since words in this context are each assumed to contain five letters, this time frame can be further refined to one-tenth of a second per letter, which is the USSC computational standard for the Message Scan. *(Note: Although it is true that sign copy is read by reference to the words comprising the message, USSC elects to achieve greater precision in the calculation process by reference to the individual letters making up the words, in order to minimize any potential skewing effect of large or small words.)*

Additionally, symbols, such as directional arrows, or universally recognized logos or icons displayed on the sign, are considered equivalent to one word, or five letters, yielding a reading, or scan time, of one-half second per symbol. Although reading time for universally recognized symbols has been shown to be at least equal to the reading time per word, it is not known to what extent reading time would be increased if unfamiliar symbols or icons were used. Understandably, the viewer would require more time for interpretation and processing if the symbols were not familiar. Therefore, the USSC standard for computation is based on the use of universally recognizable symbols only.

In addition to the reading time, research based on eye-movement studies indicates that motorists feel compelled to glance back at the road for at least one-half second for every two and one-half seconds of reading time. Within complex driving environments, the USSC Best Practices Standards increases this re-orientation with the road from one-half second to one second to account for the heightened difficulty of the driving task incurred by the additional visual demands of reading a sign.

The Driving Maneuver

When a motorist detects a sign indicating a sought-after location, s/he will respond by executing some form of driving maneuver. Depending on the number of lanes of traffic, traffic volume, and complexity of the driving environment, potential reactions may include signaling, deceleration, braking, changing lanes, and turning either right or left to gain access to the desired location.

The time interval needed to complete the driving maneuver may or may not be included in the computation of Viewer Reaction Time, depending on whether or not such maneuver must be made before (pre-sign) or after (post-sign) the sign location is passed. Generally, since on-premise identity signs are designed to mark the specific location of a given business or institutional entity, driving maneuvers necessary for entry into that location must be executed before passing the sign. The driving maneuver component, then, will be included as part of Viewer Reaction Time.

On the other hand, signs containing directional and/or wayfinding information, or other signs (such as projecting signs in crowded cityscapes) not directing ingress to the location of the sign, do not necessarily require any driving maneuver to be made until after the sign is passed. In these instances, the driving maneuver is not incorporated as part of Viewer Reaction Time.

The USSC standard for the Driving Maneuver varies from four to six seconds depending on roadside complexity and traffic volume.

Table 2. Computation of Viewer Reaction Time

Viewer Reaction Time

Computation Relative to Primary Message

	Driving Environment		
Task	Simple	Complex[1]	Multi Lane[2]
Detection	0.5 Second	1 Second	1 Second
Message Scan	0.1 Sec / Letter 0.5 Sec / Symbol	0.1 Sec / Letter 0.5 Sec / Symbol	0.1 Sec / Letter 0.5 Sec / Symbol
Re-Orientation Scan	0.02 Sec / Letter 0.1 Sec / Symbol	0.04 Sec / Letter 0.2 Sec / Symbol	0.04 Sec / Letter 0.2 Sec / Symbol
Maneuver	4 Seconds	5 Seconds	6 Seconds

1. Developed town or city commercial areas. Single or multi-lane travel under 35 mph
2. Developed urban/suburban commercial areas. Multi-lane travel over 35 mph

The computation table above is designed to provide a reasonably accurate assessment of the minimum Viewer Reaction Time for a motorist, with at least the 20/40 visual acuity necessary to maintain a driving license, to view an individual sign. Because of the significant variations that can exist in individual sign design and placement, motorist response, and the roadside environment in which the sign is placed, the table is intended as a guideline only and not as a substitute for actual field observation.

Viewer Reaction Time – Average Standard

Although the computation chart provides a useful guideline for the Viewer Reaction Time ascribed to a particular sign, it can also be used to approximate a broad average for a variety of signs within a particular landscape. This average

Viewer Reaction Time is helpful in preparing sign size limits for a planned development, a community sign system, or a series of highway oriented and/or wayfinding signs, among others. Assuming a message content of six words (30 letters) on a typical sign, the USSC standard Viewer Reaction Time average in simple environments for pre-sign maneuver is 8 seconds; and for post-sign maneuver, 4 seconds. In complex or multi lane environments, the pre-sign maneuver average advances to 10 or 11 seconds, respectively, and the post-sign maneuver average advances to 5 or 6 seconds.
Table 2 below details these average Viewer Reaction Time values through the range of traffic conditions.

Table 3. Average Viewer Reaction Time

Road Conditions	Maneuver	
	Pre Sign	Post Sign
Simple	8 Sec.	4 Sec.
Complex	10 Sec.	5 Sec.
Multi Lane	11 Sec.	5 Sec.

Average Viewer Reaction Time

Viewer Reaction Distance: Converting Time to Distance

Viewer Reaction Distance represents the distance in lineal feet that a viewer will cover at a given rate of speed during the Viewer Reaction Time interval. Essentially, Viewer Reaction Distance represents the same visual dynamic as Viewer Reaction Time, except it is expressed in lineal feet instead of seconds of elapsed time.

Viewer Reaction Distance is essential to the determination of sign legibility and size. The distance between the viewer and the sign at the point of initial detection determines the letter height necessary for the viewer to acquire and understand the message. By converting Viewer Reaction Time to Viewer Reaction Distance, a relatively precise calculation of initial detection distance can be established.

Viewer Reaction Distance, expressed in feet, can be calculated by first converting travel speed in miles per hour (MPH) to feet per second (FPS) by using the multiplier, 1.47.

FPS = (MPH) 1.47

Viewer Reaction Distance (VRD) is then calculated by multiplying feet per second by the Viewer Reaction Time (VRT).

The following is the resultant equation:

VRD = (MPH) (VRT) 1.47

Letter Height / The USSC Standard Legibility Index

The overall legibility of a sign is, essentially, a function of the height, color, and font characteristics of the letters making up its message component. For the publication, *Sign Legibility: The Impact of Color and Illumination*, test track studies of individual signs were conducted, using subjects in all age groups, to determine the effect that different conditions of daylight and darkness have on detecting and reading signs of varying colors. In order to simulate real-world conditions, two letterforms, Helvetica and Clarendon, were chosen for the study, as they best represent the two general letterform families used in the English language: sans-serif Gothic style (Helvetica) and serif Roman style (Clarendon). The research produced a definitive understanding of the legibility of letterforms under many color and illumination conditions, as well as an understanding of the letter heights necessary for legibility over varying distances from the observer.

Figure 2. Helvetica and Clarendon Letterforms

Using this research not only as a benchmark for the specific letterforms studied, but also as a reasonable basis for extrapolation to other similarly configured letterforms, USSC developed a Standard Legibility Index. By means of the Index, the height of letters necessary to provide legibility from a given distance can be calculated.

The USSC Standard Legibility Index is a numerical value representing the distance in feet for every inch of capital letter height at which a sign may be read. The table also reflects the 15 percent increase in letter height required when all upper case letters (all caps) are used instead of upper and lower case letters with initial caps, a difference in recognition distance documented in earlier studies by the researchers at the Pennsylvania Transportation Institute.

To use the table to determine letter height for any given viewing distance, select the combination of illumination, letter style, letter color, and background color that most closely approximates those features on the sign being evaluated. Then, divide the viewing distance (in feet) by the appropriate Legibility Index value. The result is the letter height in inches for the initial capital letter in upper and lower case configurations, or for every letter in an all caps configuration.

$$\text{Letter Height} = \frac{\text{VRD}}{\text{Legibility Index}}$$

Letter height is expressed in inches, and the Viewer Reaction Distance (VRD) in feet.

Table 4. The USSC Standard Legibility Index

ILLUMINATION	LETTER STYLE	LETTER COLOR	Background COLOR	LEGIBILITY INDEX	
				Upper & Lower Case	ALL CAPS
External	Helvetica	Black	White	29	25
External	Helvetica	Yellow	Green	26	22
External	Helvetica	White	Black	26	22
External	Clarendon	Black	White	28	24
External	Clarendon	Yellow	Green	31	26
External	Clarendon	White	Black	24	20
Internal Translucent	Helvetica	Black	White	29	25
Internal Translucent	Helvetica	Yellow	Green	37	31
Internal Translucent	Clarendon	Black	White	31	26
Internal Translucent	Clarendon	Yellow	Green	37	31
Internal Opaque	Helvetica	White	Black	34	29
Internal Opaque	Helvetica	Yellow	Green	37	31
Internal Opaque	Clarendon	White	Black	36	30
Internal Opaque	Clarendon	Yellow	Green	37	28
Neon	Helvetica	Red	Black	29	25
Neon	Helvetica	White	Black	38	32

Illumination Variations:

External light source

Internal light source with fully translucent background

Internal light source with translucent letters and opaque background

Exposed neon tube

Legibility Index – Average Standard

30

In addition to the specific legibility ranges provided by the chart, an average Legibility Index value can be used in some situations. For instance, if a committee wishes to set code limits for average size ranges for a community sign system, or to set letter height and size limits for a highway or community wayfinding system, an average Legibility Index value of 30 may be used. However, it must be understood that this is an average only and, as such, may fall short of meeting the legibility needs of any specific sign or environment.

Legibility Index – Environmental Adjustment

In *Real World On-Premise Sign Visibility, The Impact of the Driving Task on Sign Detection and Legibility* (Pennsylvania Transportation Institute 2002), a marked difference was documented between legibility index results obtained from the relatively distraction free test track environment (as detailed in table 4), and observations taken from real-world driving situations involving increased levels of driver workload in complex and/or congested environments.

Both the research team at PTI, as well as a similar team studying the impact of the driving task on sign legibility (Chrysler, et al. 2001), arrived at the same essential conclusion; notably that the driving task, particularly in environments involving a high degree of visual stimuli, produces a significant reduction in the basic test track legibility index values.

This reduction, or legibility index deterioration, is essentially a manifestation of delayed detection caused by increased driver workload, and is clearly measurable as a percentage decrease in the standard legibility index. In a comparison analysis of the test track values versus values produced from real world observation, an average decrease of at least thirty-five percent of the standard legibility index values was documented, with extreme values as low as seven feet of distance per inch of letter height in highly complex environments. In general, and across a median range of complexity, this decrease can conservatively result in a reduction in the average legibility index value of 30 feet of distance per inch of letter height to 20 feet of distance per inch of letter height, particularly as the complexity of the driver's visual load is increased.

Accordingly, in both moderate to highly congested zones in which demands on driver attention are high, USSC recommends the application of an adjustment factor designed to bring the standard legibility index values into alignment with the real world driving conditions encountered by drivers in those zones. The adjustment factor is applied by multiplying the standard legibility index value by the adjustment factor. The product is the adjusted legibility index for the zone.

Adjustment Factors:

1). For moderately congested strip, in-town, or in-city zones, usually characterized by some of the following environmental conditions:

Moderate pedestrian and/or vehicular activity
Traffic signal or traffic sign control at major intersections
Intermittent "stop and go" traffic patterns
On street Parking
Posted speeds below 40 MPH
Tightly spaced retail locations

Apply Adjustment Factor of 0.83

Or as an equation; Adjusted Moderate Complexity LI = (Standard LI) 0.83

Thus, in moderately congested zones, the average legibility index value of 30 would be adjusted to 25, and individual index values adjusted accordingly. In highly congested zones, (as characterized in 2 below) the average legibility index value would be adjusted from 30 to 20 feet/inch.

2). For highly congested strip, in-town, or in-city zones
usually characterized by some of the following environmental conditions:

High pedestrian and/or vehicular activity
Traffic signal or traffic sign control at most intersections
Intermittent “stop and go” traffic patterns
On street parking
Posted speeds below 30 MPH
Tightly spaced retail locations

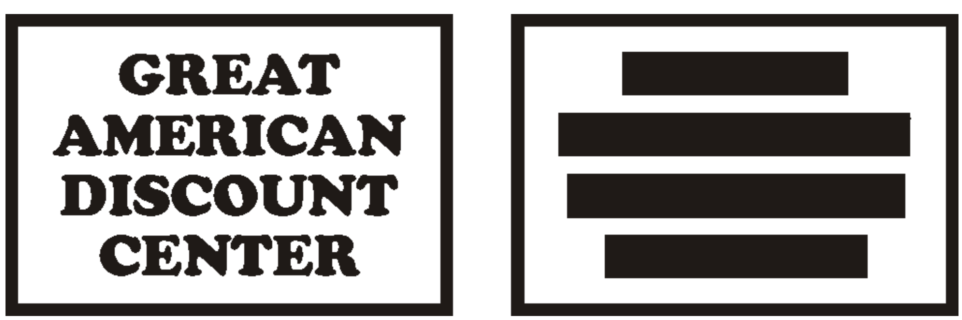
Apply Adjustment Factor of 0.67

Or as an equation; Adjusted High Complexity LI = (Standard LI) 0.67

Copy Area

The copy area of a sign is that portion of the sign face encompassing the lettering and the space between the letters (letterspace), as well as any symbols, illustrations, or other graphic elements. It is a critical component of effective sign design because it establishes the relationship between the message and the negative space necessary to provide the sign with reasonable legibility over distance.

Figure 3. Copy Area

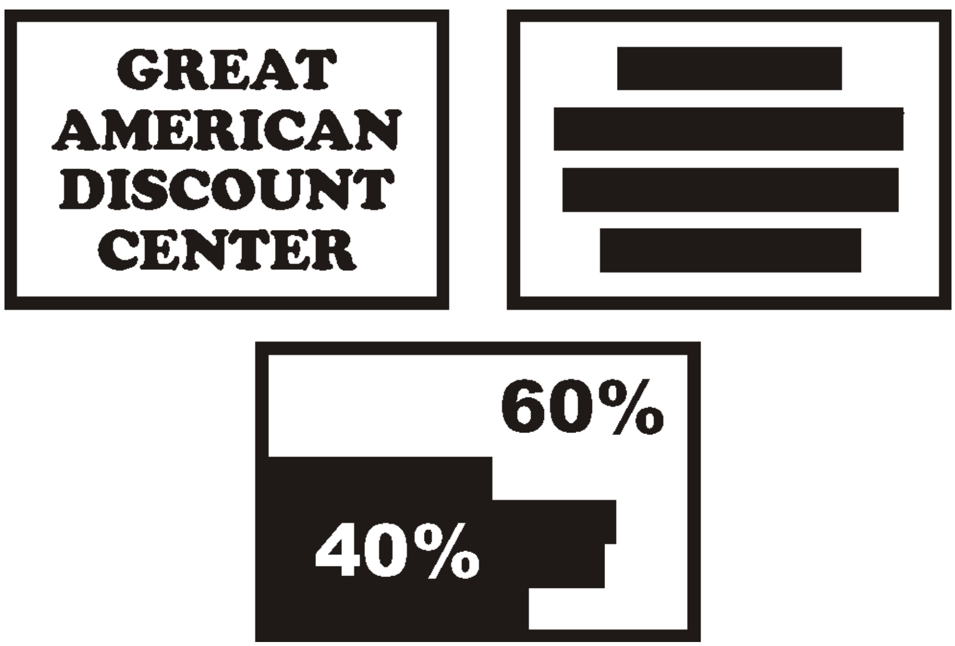


The illustration on the left depicts a typical on-premise sign face; while the one on the right, with black rectangles covering the copy area, affords a visual of the message layout

Negative Space

Negative space is the open space surrounding the copy area of a sign. It is essential to legibility, particularly in signs in which the copy is displayed within a background panel. Negative space should never be less than 60 percent of the copy area on any given background. This requirement for a 40/60 relationship between the copy area and negative space is the minimum USSC standard. It is intended only to establish a measurable baseline for the negative space component of a sign, such that a reasonable expectation of legibility will exist.

Figure 4. Relationship Between Copy Area And Negative Space



The bottom sign panel illustrates how the aggregate copy area comprises 40 percent of the total sign panel area, with the remaining 60 percent forming the negative space area.

DETERMINING SIGN SIZE – Calculation Methodology

The size of a sign is determined by the size and length of the message and the time required to read and understand it. It can be calculated once the numerical values of the five size determinants –Viewer Reaction Time, Viewer Reaction Distance, Letter Height, Copy Area, and Negative Space – have been established.

The step-by-step process to determine sign size, which is explained below, is useful not only as a calculation method, but also as a means of understanding the elements involved in the calculation.

Area of Sign / Computation Process:

1. Determine speed of travel (MPH) in feet per second (FPS): (MPH x 1.47).
2. Determine Viewer Reaction Time (VRT).
3. Determine Viewer Reaction Distance (VRT x FPS).
4. Determine Letter Height in inches by reference to the Legibility Index (LI): (VRD/LI).
5. Determine Single Letter Area in square inches (square the letter height to obtain area occupied by single letter and its adjoining letterspace).
6. Determine Single Letter Area in square feet: Single Letter Area in square inches/144.
7. Determine Copy Area (Single Letter Area in square feet x total number of letters plus area of any symbols in square feet).
8. Determine Negative Space Area at 60% of Copy Area (Copy Area x 1.5).
9. Add Copy Area to Negative Space Area.
10. Result is Area of Sign in square feet.

Computation Process / Calculation Example

Figure 5. Calculation Example Sign

Location: Complex Driving Environment
Posted Traffic Speed of 40 MPH

Sign Background: White
Sign Copy: 23 Letters, Upper & Lower Case
Clarendon Style, Black
Internally Illuminated, Translucent Face

1. Determine speed of travel in feet per second; 40 MPH x 1.47 = 59 FPS
2. Determine Viewer Reaction Time - Refer to Table 2
   Detection (Complex Environment) …………..... 1 second
   Message Scan - 23 letters x 0.1………………2.3 seconds
   Re-orientation Scan - 23 letters x .04…..……0.9 seconds
   Maneuver………………….…………………5 seconds
   Total Viewer Reaction Time (rounded) = 9 seconds VRT
3. Determine Viewer Reaction Distance; 59 (FPS) x 9 (VRT) = 530 feet
4. Determine Letter Height in inches - Refer to Legibility Index, Table 4
   Black Clarendon letters on White background = Index of 31
   530 (VRD) / 31 (LI) = 17 inch letter height
5. Determine Single Letter Area in square inches
   17 x 17 = 289 square inches, single letter area
6. Determine Single Letter Area in square feet
   289 / 144 = 2 square feet, single letter area
7. Determine Copy Area; single letter area (sq. ft.) x number of letters
   2 x 23 = 46 square feet, copy area
8. Determine Negative Space @ 60% of copy area
   46 x 1.5 = 69 square feet, negative space
9. Add Copy Area to Negative Space
   46 + 69 = 115 square feet
10. Result is Area of Sign, 115 square feet

Area of Sign – Equation / Specific Usage

In addition to the computation method above, the USSC has developed an algebraic equation to determine the Area (A_{sign}) for signs containing letters only, which will provide the same result but will simplify the process. The equation allows for insertion of all of the size determinants, except for Negative Space, which is fixed at the standard 40/60 ratios. (Note: If numbers are rounded off in the computation process, a very slight difference in result may occur between the computation process and the equation).

$$A_{sign} = \frac{3n}{80}\left[\frac{(VRT)\,(MPH)}{LI}\right]^2$$

Fixed Value:
- 40/60 ratio, letters/negative space

Variable Values:
- Number of Letters (n)
- Viewer Reaction Time (VRT)
- Miles Per Hour (MPH)
- Legibility Index (LI)

Area of Sign – Equation / Broad Usage

The equation above is used to calculate the size of a sign containing letterforms when the motorist is traveling at a specific rate of speed. To allow for a broader scientific evaluation of sign size and satisfy the minimal legibility requirements across a full range of reaction times and speed zones, USSC has developed a second equation. This formula fixes the average sign size determinants, leaving only Viewer Reaction Time (VRT) and the speed of travel (MPH) as the sole variables. It can be used to ascertain the general size of signs necessary to adequately and safely convey roadside information to motorists traveling at a given rate of speed as well as to establish size parameters for signs across an entire community and/or road system. Table 5 below provides some examples of the use of the equation.

$$A_{sign} = \frac{[(VRT)(MPH)]^2}{800}$$

Fixed Values:
- 30 Letters
- Legibility Index (LI) of 30
- 40/60 ratio, letters/negative space

Variable Values:
- Viewer Reaction Time (VRT)
- Miles Per Hour (MPH)

Table 5. Sign Size As Function Of Travel Speed And Viewer Reaction Time

MPH	VRT (Seconds)	Sign Size (Square Feet)
25	4	12.5
	5	20
	8	50
	10	78
40	4	32
	5	50
	8	128
	10	200
55	4	60.5
	5	95
	8	242
	10	378

Sign Size as function of travel speed and Viewer Reaction Time

Sign Height – Minimum Standards for Vehicular Oriented Environments

For signs providing roadside information in primarily vehicular-oriented environments, the height above grade of the sign and/or sign copy has a pronounced effect on an approaching motorist's ability to detect and read the message displayed. As is now documented in the research publication, *Sign Visibility, Effects of Traffic Characteristics and Mounting Height*, the simple presence of other vehicles on the road (i.e., in front, in an adjacent travel lane, or in travel lanes in the opposite direction) can potentially prevent the motorist from detecting a sign. If a sign is situated at or below five feet above grade, other vehicles may block the motorist's view, and the sign copy will not be legible.

The aforementioned study used analytical algorithms reflecting known patterns of traffic flow and volume, in conjunction with computer generated simulation software. The research resulted in predictions of the percentage of times that other vehicles blocked the view of an approaching motorist, thus preventing him/her from detecting a low mounted sign (5 feet or less above grade). The percent of blockage was computed as a function of the traffic flow rate, the position of the subject motorist in the traffic stream, and the position and setback of the sign. Oversize vehicles (such as trucks, buses, and recreational vehicles) were not included in the calculations even though their normal presence in the vehicular mix would have, undoubtedly, increased the percentages noted in the study.

Eight traffic scenarios were analyzed, based on a four-lane undivided highway and either 35 or 45 miles per hour as the speed of travel. These conditions were chosen to simulate the general characteristics of roadways traversing commercial zones throughout the United States. The signs (assumed to be 10 feet wide) were located at either 10 or 20 feet from the edge of the roadway and on either the right- or left-hand side of the road. The findings clearly establish a quantifiable loss of visibility across the full range of sign placement as traffic flow rates increase. The charts, A through H, document the findings for traffic flow rates ranging from 200 to 1200 vehicles per hour.

Based on the research, the USSC minimum height standard for copy on signs placed on roads with characteristics as detailed in the charts is no less than five feet above grade. However, the USSC strongly recommends a minimum height standard for sign copy of no less than seven feet above grade in order to ensure adequate visibility and a reasonable viewer reaction time, considering the blocking potential of other vehicles on the road. The seven feet above grade recommendation is the same as the Federal Highway Administration's standard, as promulgated in the Manual of Uniform Traffic Control Devices (MUTCD), for the height above grade of official roadside directional and wayfinding signs utilized along urban roadways in the United States.

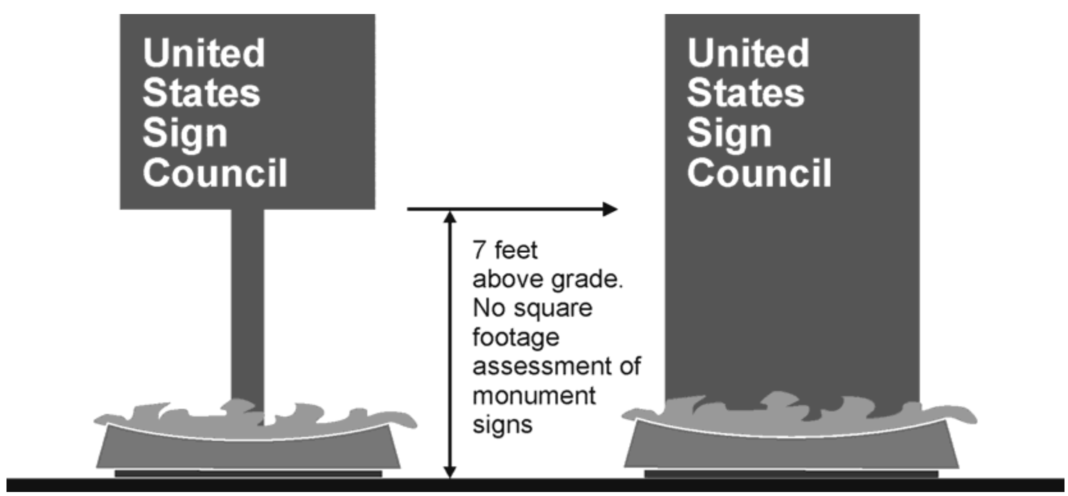
Minimum Sign Height – Regulatory Issues

As a related issue, the visibility requirement for ground or monument sign copy placement above seven feet above grade may run counter to community sign code regulation which: 1.) sets overall low maximum height limits, or 2.) computes maximum square footage limits on sign size as the simple product of the total height times the total width of the monument structure, regardless of sign copy placement. In either case, a community intent on encouraging the use of monument or monolithic type ground signs may find its sign regulations to be counter productive to its aims, as well as to the effective transfer of roadside information in moderate to high density traffic conditions.

To alleviate this condition, USSC offers the following sign code modification recommendations for use in land use zones in which the data indicate significant blockage of the copy area of low mounted or monument signs.

1.) Maximum height limits of such signs – as well as maximum height limits for other freestanding signs within the zone – should take into account the recommended lower limit of seven feet above grade for copy placement.
2.) No maximum square footage assessment of monument or monolithic type ground signs should be imposed below seven feet above grade, provided that no primary copy is placed within that area. See Figure 6 below.

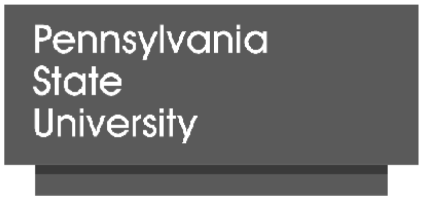
Figure 6. Comparison / Pole and Monument Signs



Sign Blocking Scenarios (Schematic)

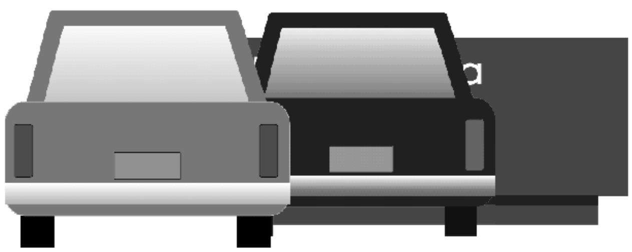
Sign Blocking Charts (Schematic)
Blocking Tables

Sign Blocking Scenarios (Schematic)



Typical
Low Mounted
Ground Sign

Single Lane
View
Blocking



Two Lane
View
Blocking

Visibility
Solution:
Maintain Sign
Design Style
Raise Copy
To Viewable Height

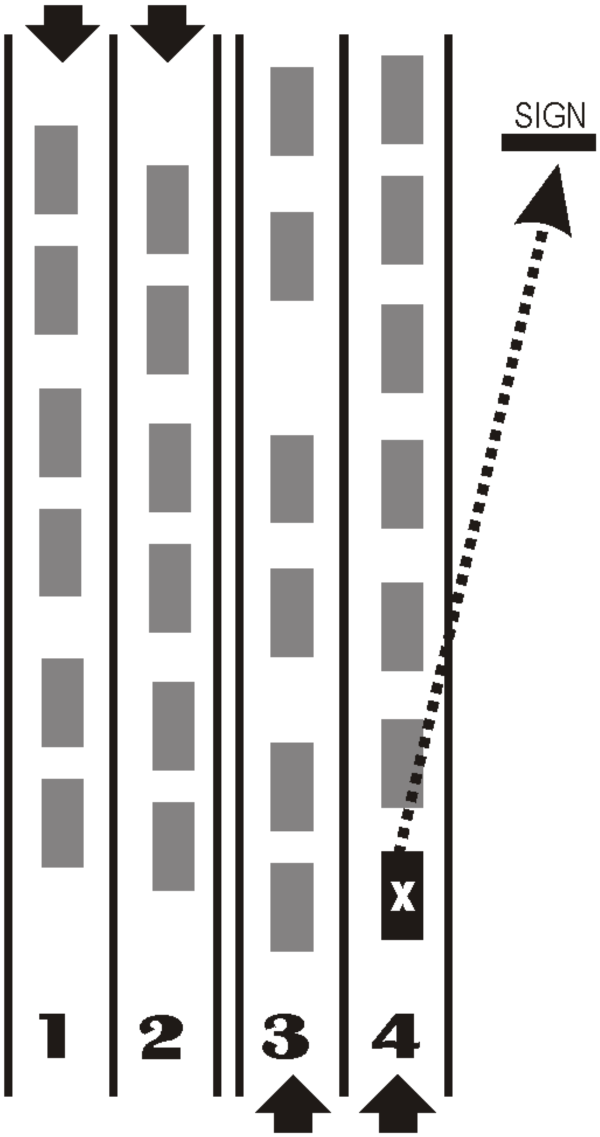


Chart A

(Schematic)

Speed of Travel

35 mph

Subject Vehicle - Lane 4
Sign on Right

Tables indicate percent of time sign is blocked from view of subject vehicle depending on Flow Rate and sign setback.

Flow Rate represents the number of vehicles traveling in both lanes in one direction for a period of one hour.

Sign Setback at 10 Feet

Flow Rate	% Blocking
200	9
400	17
600	25
800	31
1000	38
1200	43

Sign Setback at 20 Feet

Flow Rate	% Blocking
200	6
400	12
600	18
800	23
1000	28
1200	33

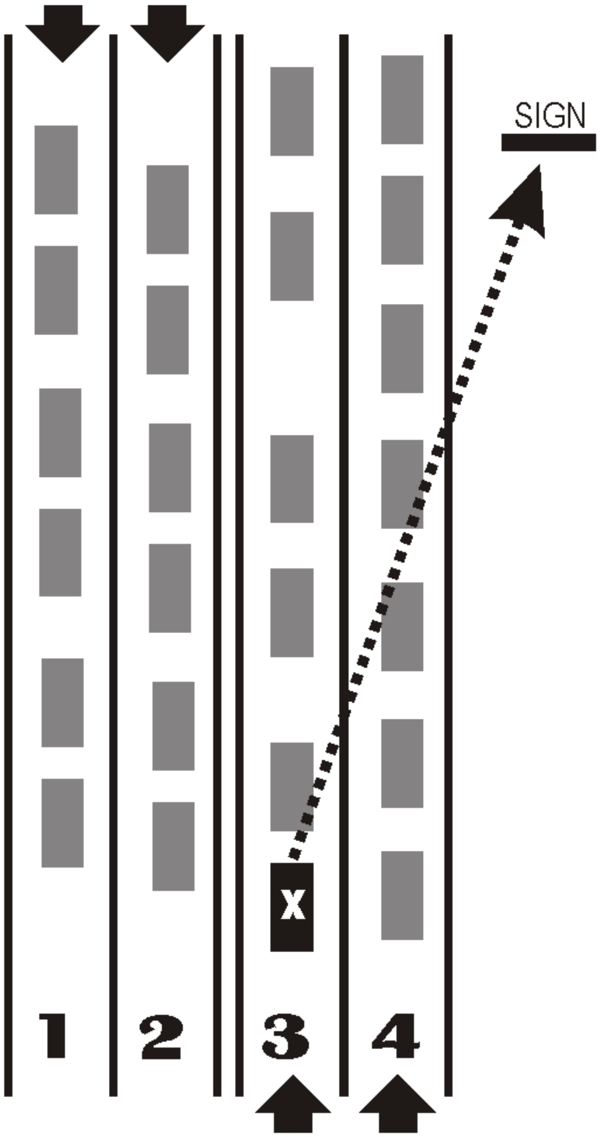


Chart B

(Schematic)

Speed of Travel

35 mph

Subject Vehicle - Lane 3
Sign on Right

Tables indicate percent of time sign is blocked from view of subject vehicle depending on Flow Rate and sign setback.

Flow Rate represents the number of vehicles traveling in both lanes in one direction for a period of one hour.

Sign Setback at 10 Feet

Flow Rate	% Blocking
200	16
400	29
600	41
800	50
1000	58
1200	65

Sign Setback at 20 Feet

Flow Rate	% Blocking
200	12
400	24
600	33
800	42
1000	49
1200	56

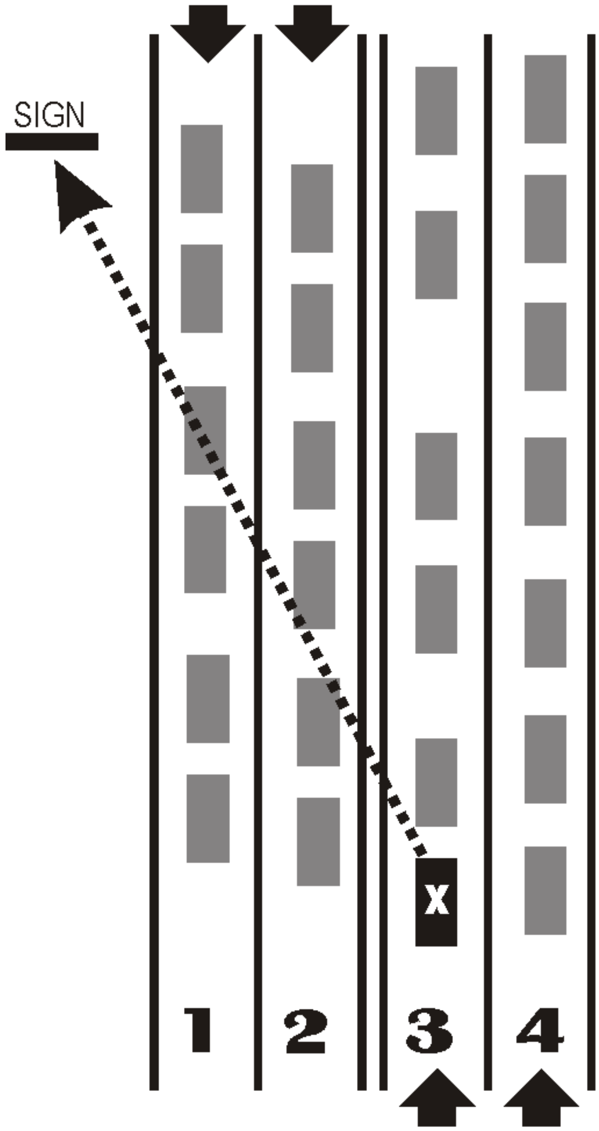


Chart C

(Schematic)

Speed of Travel

35 mph

Subject Vehicle - Lane 3
Sign on Left

Tables indicate percent of time sign is blocked from view of subject vehicle depending on Flow Rate and sign setback.

Flow Rate represents the number of vehicles traveling in both lanes in one direction for a period of one hour.

Sign Setback at 10 Feet

Flow Rate	% Blocking
200	19
400	35
600	48
800	58
1000	66
1200	72

Sign Setback at 20 Feet

Flow Rate	% Blocking
200	16
400	30
600	41
800	51
1000	59
1200	65

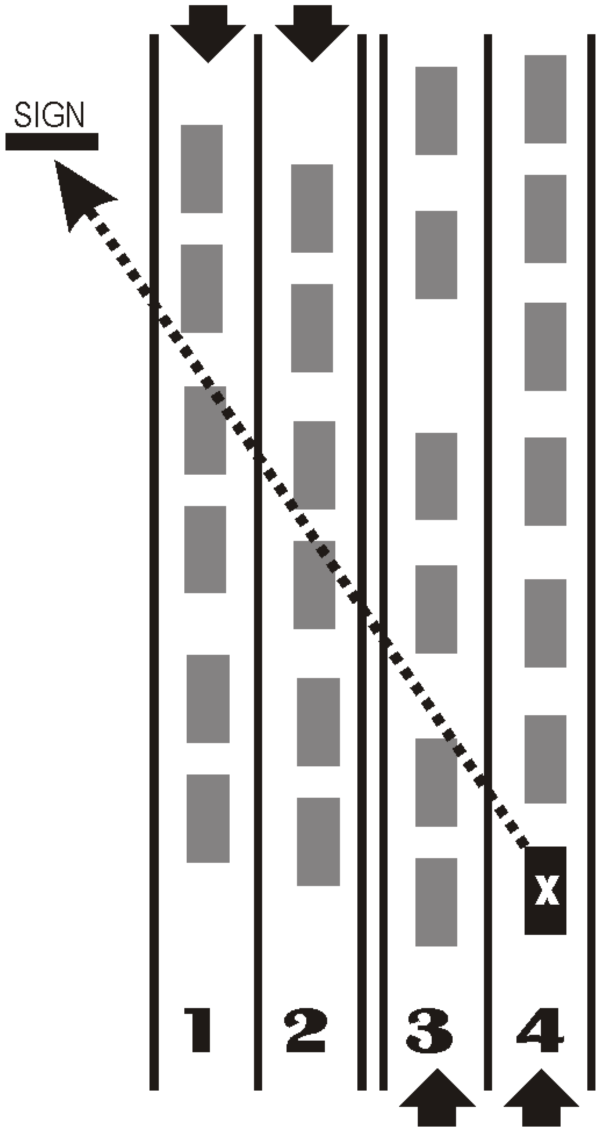


Chart D

(Schematic)

Speed of Travel

35 mph

Subject Vehicle - Lane 4
Sign on Left

Tables indicate percent of time sign is blocked from view of subject vehicle depending on Flow Rate and sign setback.

Flow Rate represents the number of vehicles traveling in both lanes in one direction for a period of one hour.

Sign Setback at 10 Feet

Flow Rate	% Blocking
200	23
400	41
600	54
800	65
1000	73
1200	79

Sign Setback at 20 Feet

Flow Rate	% Blocking
200	20
400	36
600	49
800	59
1000	67
1200	74

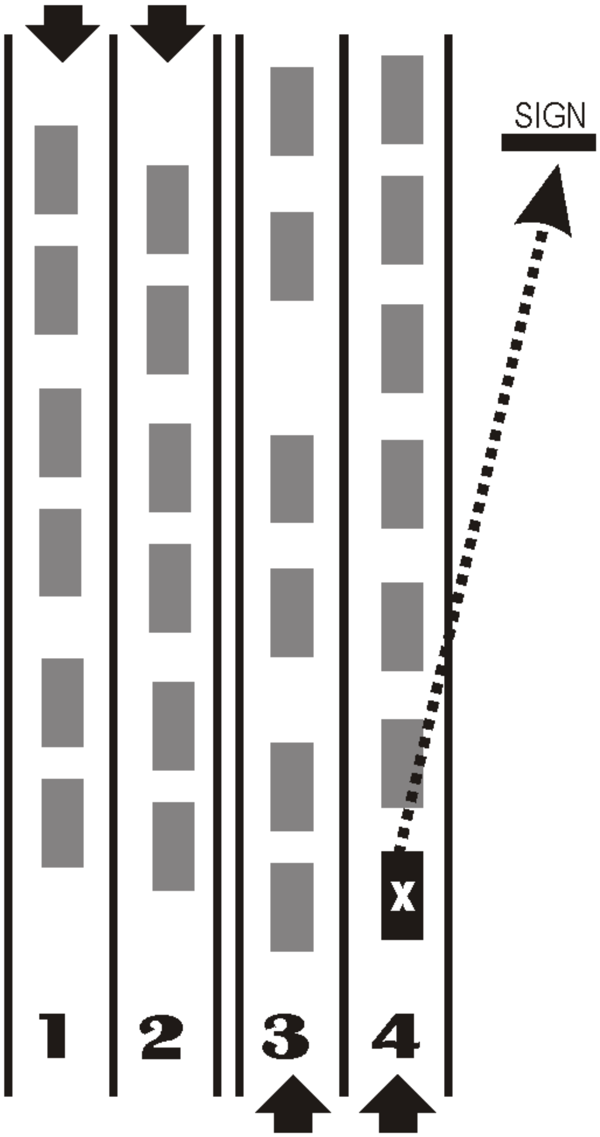


Chart E

(Schematic)

Speed of Travel

45 mph

Subject Vehicle - Lane 4
Sign on Right

Tables indicate percent of time sign is blocked from view of subject vehicle depending on Flow Rate and sign setback.

Flow Rate represents the number of vehicles traveling in both lanes in one direction for a period of one hour.

Sign Setback at 10 Feet

Flow Rate	% Blocking
200	9
400	17
600	24
800	31
1000	37
1200	42

Sign Setback at 20 Feet

Flow Rate	% Blocking
200	6
400	12
600	17
800	23
1000	27
1200	32

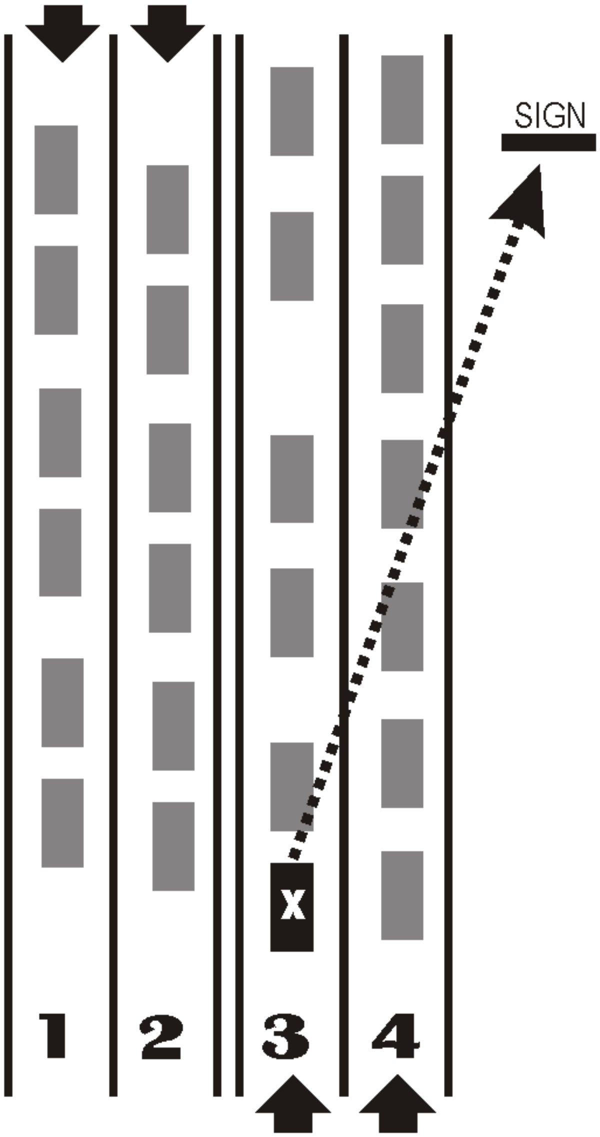


Chart F
(Schematic)

Speed of Travel

45 mph

Subject Vehicle - Lane 3
Sign on Right

Tables indicate percent of time sign is blocked from view of subject vehicle depending on Flow Rate and sign setback.

Flow Rate represents the number of vehicles traveling in both lanes in one direction for a period of one hour.

Sign Setback at 10 Feet

Flow Rate	% Blocking
200	16
400	29
600	40
800	49
1000	57
1200	64

Sign Setback at 20 Feet

Flow Rate	% Blocking
200	12
400	23
600	32
800	41
1000	48
1200	54

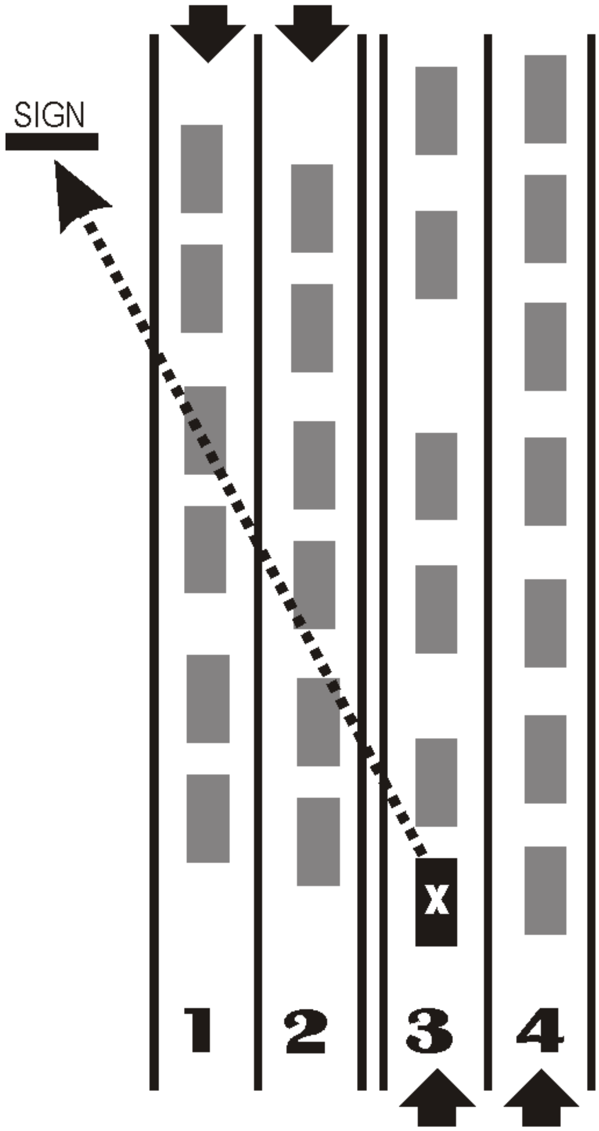


Chart G

(Schematic)

Speed of Travel

45 mph

Subject Vehicle - Lane 3
Sign on Left

Tables indicate percent of time sign is blocked from view of subject vehicle depending on Flow Rate and sign setback.

Flow Rate represents the number of vehicles traveling in both lanes in one direction for a period of one hour.

Sign Setback at 10 Feet

Flow Rate	% Blocking
200	19
400	34
600	46
800	56
1000	64
1200	70

Sign Setback at 20 Feet

Flow Rate	% Blocking
200	16
400	29
600	40
800	49
1000	57
1200	63

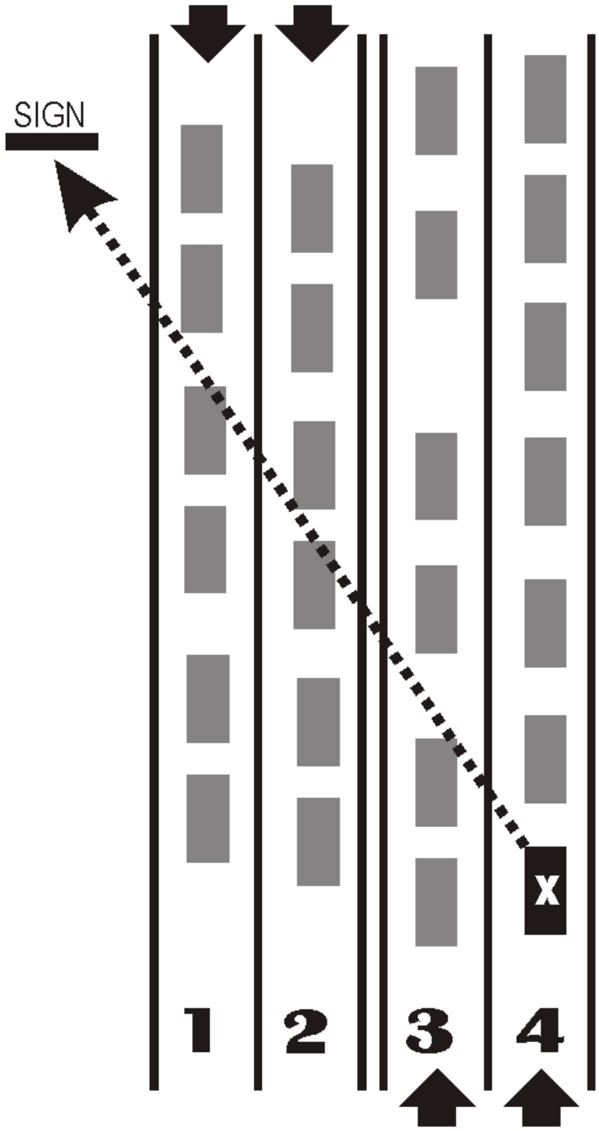


Chart H

(Schematic)

Speed of Travel

45 mph

Subject Vehicle - Lane 4
Sign on Left

Tables indicate percent of time sign is blocked from view of subject vehicle depending on Flow Rate and sign setback.

Flow Rate represents the number of vehicles traveling in both lanes in one direction for a period of one hour.

Sign Setback at 10 Feet

Flow Rate	% Blocking
200	22
400	39
600	52
800	63
1000	71
1200	77

Sign Setback at 20 Feet

Flow Rate	% Blocking
200	19
400	34
600	47
800	57
1000	65
1200	71

Parallel Signs

The United States Sign Council On-Premise Sign Standards, published in 2003, were based on numerous university level scientific studies conducted by the United States Sign Council (USSC) and its research arm, The United States Sign Council Foundation, aimed at quantifying various aspects of on-premise sign functionality, including sign size, legibility and height for on-premise signs that are oriented in a perpendicular fashion to the driver. These signs are typically referred to as freestanding signs, pylon signs, monument signs, projecting signs or any type of sign that is situated alongside a roadway and is installed in a perpendicular fashion to the roadway and facing a driver's line of sight.

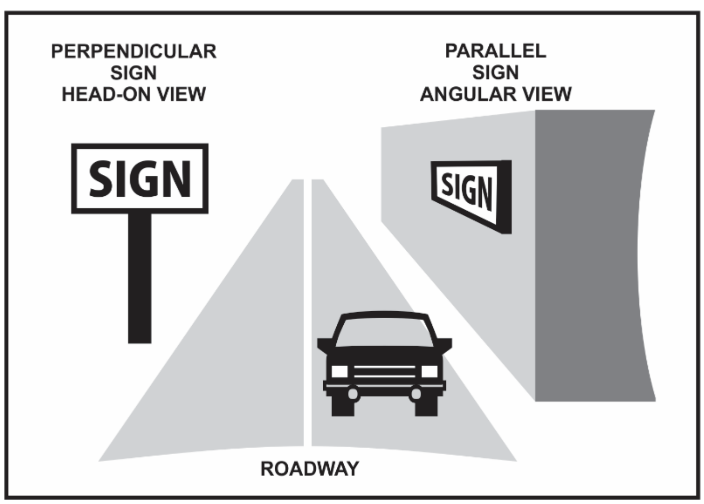
Research performed in 2006 extended this inquiry to the subject of "parallel" signs. Parallel signs present unique challenges for the driver. Parallel signs are often referred to as wall signs, building signs, façade signs, and other terminology used to denote on-premise signs that are affixed to a building structure, and are typically presented in an orientation that is parallel to the roadway and the driver's line of sight, instead of perpendicular to it.

On-Premise Signs: Determination of Parallel Sign Legibility and Letter Heights, Pennsylvania State University (2006) describes the development of, and rationale for, a mathematical model that calculates letter heights for parallel-mounted on-premise signs. The parallel sign research integrated the original legibility standards described earlier in these standards, so that the letter heights developed for perpendicular signs form the basis for letter heights on parallel signs with various lateral offsets (distance from the edge of the roadway to the sign).

Unique factors presented by Parallel Signs

A parallel on-premise sign is more difficult to read because of its orientation, or tilt, with respect to the driver. This orientation makes it impossible to see the sign face at certain distances and offsets (Figure 7). Even when a driver can see the sign face, the sign content is often foreshortened and distorted. A driver must get close to the sign in order to increase the viewing angle to the point where the sign becomes legible. Yet, as a driver approaches the sign, the time available to read the sign becomes shorter, and the sign moves further into the driver's peripheral vision. Therefore, parallel signs must be read using a series of very quick glances at large visual angles during small windows of viewing opportunity. Because of this, the letter heights previously developed for perpendicular signs, where drivers have more time and can take longer straight ahead glances, do not provide adequate parallel sign legibility.

Figure 7. Parallel Sign and Perpendicular Sign Comparison



Components related to Parallel Sign Legibility

Researchers have identified multiple factors that assist in the construction of a comprehensive model for the determination of parallel sign letter heights for signs along typical roadway cross-sections (number of lanes) and lateral sign offsets.

1. Glance Angle: The maximum angle at which drivers look away from the road to read signs.
2. Glance Duration: The length of time drivers look away from the road to read signs.
3. Glance Frequency: The number of glances that drivers make at any given sign.
4. Sign reading speed.
5. Observation Angle: The angle, or tilt, at which signs become legible.

Glance Angle

As discussed earlier in the Standards, sign detectability and legibility are, among other things, functions of sign orientation, or the relative angle of view between the sign and the driver. This angle is at its optimum level when the sign is positioned perpendicular to the driver and within driver's cone of vision at the initial point of detection (see Figure 1). Parallel signs typically have a large lateral offset, or are set back in a location that is outside the driver's cone of vision, to the left or to the right. This increases the driver's Glance Angle, and makes it more difficult to detect and read the sign.

Glance Duration

Researchers have found that drivers take their attention away from the forward roadway and glance at signs outside their cone of vision for varying lengths of time. The range for Glance Duration based on research extends from very short “look away” times to read signs to one second glances to two second and greater glance durations.

The USSC Best Practices Standards assumes the following based on research:

> Drivers directed the majority of their visual attention to areas of the roadway that were relevant to the task at hand (i.e., the driving task).
>
> Drivers look away from the forward roadway to view signs located outside a driver’s cone of vision for varying amounts of time.
>
> The key for parallel sign visibility and legibility is to afford the driver adequate time and distance to see and read a parallel sign within the duration of a typical glance or glance period.

Glance Frequency

Researchers in the 2006 parallel sign study stated that drivers typically glance at signs along the roadway at a frequency of 1 to 2 times, assuming they look at signs in any fashion. The number of glances that a driver can perform regarding a sign is limited, however, by the time and distance that is available to the driver to perform the viewing function. For instance, if a driver has a maximum window of 7 seconds to detect and read an on-premise parallel sign (see discussion of Viewer Reaction Time in this Chapter), and looks at the sign beginning at the first second of the Viewer Reaction Time sequence, and glances for a full 2 seconds, and then returns his or her attention to the forward roadway for 2 seconds, then only one additional glance at the maximum 2 seconds is physically possible before the sign is outside the view of the driver. Therefore, parallel signs need to be visible and legible for drivers within a 2-glance period in general.

Sign Reading Speed

The USSC Foundation research determined that parallel roadside signs are read, and can only be read, in short spurts as the driver looks from the road to the sign and back to the road again. This type of reading task is termed “glance legibility”, for which reading speed is a critical element. An important factor in this calculation is how long it takes a driver to read a roadside sign and how to maximize sign reading speed in order to minimize the time a driver must look away from the road.

Typical adult text reading speed, for a book or an electronic monitor, is roughly 250 words per minute, or 4.2 words per second. Research on highway sign reading indicates that it takes drivers between 0.5 to 2.0 seconds to read and process a single sign word or unit of information (note that this is two to eight times slower than normal reading speed). Therefore, a concept known as the “acuity threshold” helps explain some of the disparity between normal reading speed and the time it takes to read a roadside sign.

Drivers begin to read signs as soon as they become legible; but at the lower threshold of legibility – the acuity threshold - the reading task is slower. Optimum legibility begins at the point of “critical print size,” defined as the smallest letter height necessary for maximum reading speed.

Parallel sign letter size needs to be increased or adjusted upward as compared to the threshold letter height in order to increase reading speed for drivers and achieve the critical print size. It is essential to optimize reading speed for parallel mounted signs in order to minimize the duration and frequency of glances that drivers must make at these signs and to maximize the time they have for the primary visual driving tasks and the roadway forward.

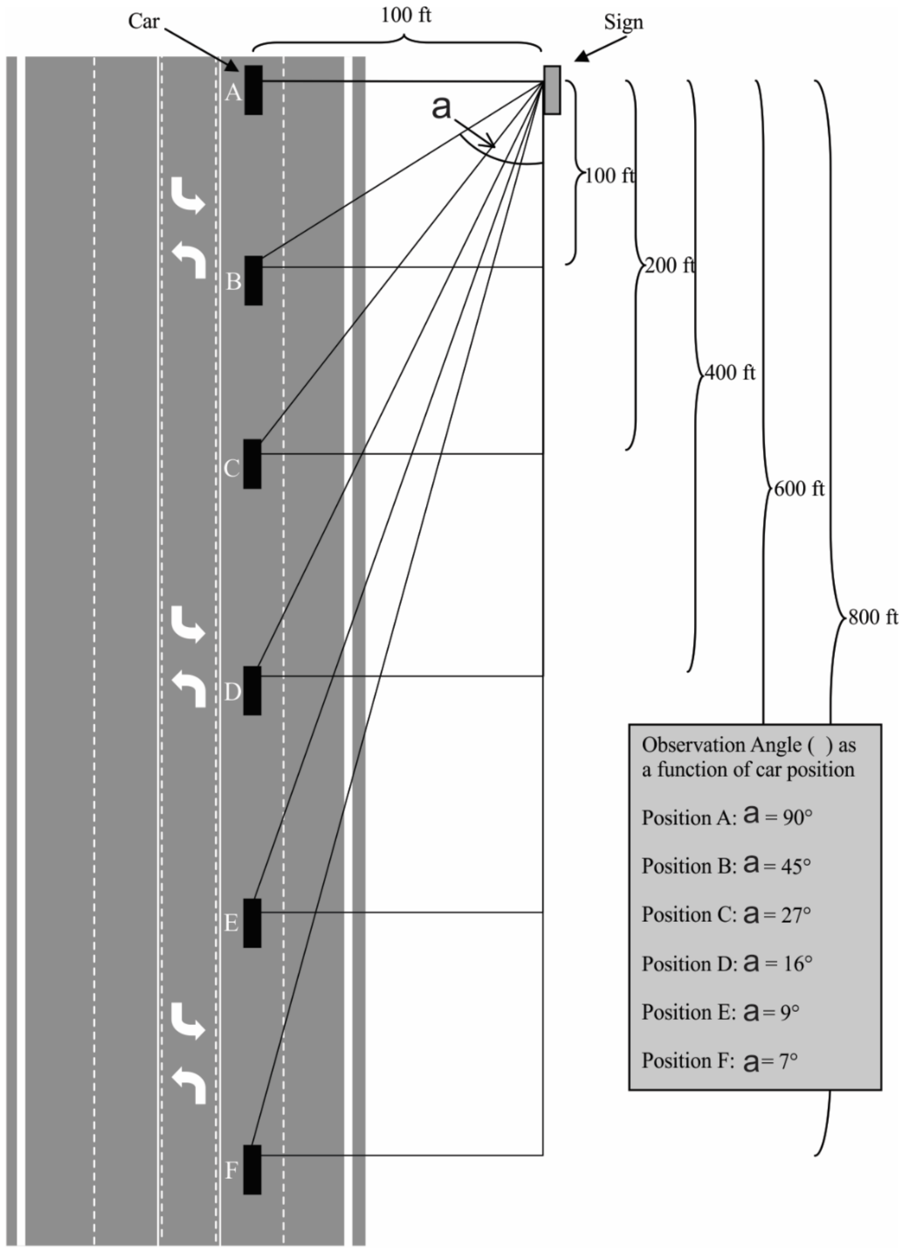
The research shows that drivers read the fastest at two to three times threshold letter height. To ensure adequate letter height across a variety of scenarios and environments, a multiplier of three times threshold was selected for use in the standard. Utilizing this threshold letter height improves the likelihood that drivers will be able to begin reading signs at the initial 30° observation angle (see below).

Observation Angle

As a driver gets closer to a parallel mounted sign (a typical wall sign or building sign), the driver's glance angle increases from nearly 0° when the driver is far down the road, to 90° when the driver is beside the sign (Figure 8). At 90°, a sign is optimally legible. However, it is at a glance angle where the sign can only be viewed through either the passenger or driver side window, presenting the driver with an inappropriate choice in terms of maintaining attention to the roadway forward, or turning at a substantial angle to view the sign.

Researchers found that signs begin to be legible at a "threshold observation angle" somewhere between 0° and 90°. The USSC standard threshold angle is 30°. Optimum parallel sign legibility extends from 30° to 60°; that is, when the driver has an observation angle to the target sign within these parameters. Legibility of the sign message deteriorates above and below these benchmarks. Finally, increasing parallel sign letter height improves driver performance and sign legibility.

Figure 8. Change in observation angle with distance



Parallel Sign and Letter Size

The minimum distance at which a sign and letters become legible is a function of the time it takes to read the sign or letters and the decisions and maneuvers required to comply with the message. Parallel sign and letter legibility is a function of both time and distance. See Table 5 for appropriate letter heights for perpendicular mounted signs. The overall standard Legibility Index (LI) for perpendicular signs is 30; that is, a 1” letter is legible from a 30’-0” viewing distance.

As discussed above, restricted viewing angles curtail parallel sign sight distance. The MALD or Maximum Available Legibility Distance for a parallel sign is the sight distance between the driver and the sign at the angle where the sign first becomes legible. This distance is calculated using the number of travel lanes, the sign’s lateral offset from the curb, and the threshold observation angle discussed above.

Table 6. Window of opportunity to read parallel signs (in seconds)

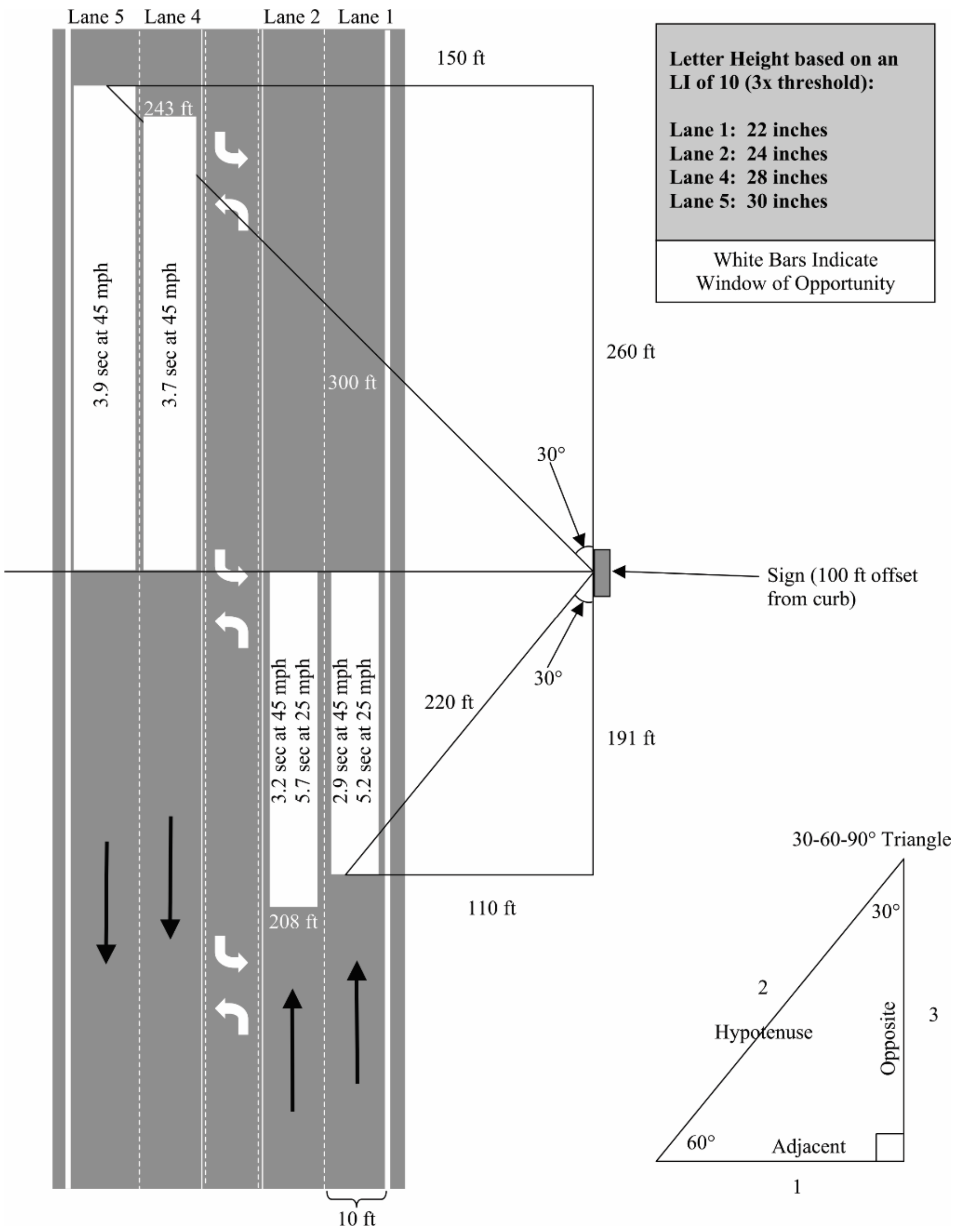
25 mph Speed Limit

Offset from Curb	Number of Lanes 1	2	3	4	5
10	0.94	1.42	1.89	2.36	2.83
20	1.42	1.89	2.36	2.83	3.31
40	2.36	2.83	3.31	3.78	4.25
60	3.31	3.78	4.25	4.72	5.20
80	4.25	4.72	5.20	5.67	6.14
100	5.20	5.67	6.14	6.61	7.09
125	6.38	6.85	7.32	7.79	8.27
150	7.56	8.03	8.50	8.98	9.45
175	8.74	9.21	9.68	10.16	10.63
200	9.92	10.39	10.86	11.34	11.81

45 mph Speed Limit

Offset from Curb	Number of Lanes 1	2	3	4	5
10	0.52	0.79	1.05	1.31	1.57
20	0.79	1.05	1.31	1.57	1.84
40	1.31	1.57	1.84	2.10	2.36
60	1.84	2.10	2.36	2.62	2.89
80	2.36	2.62	2.89	3.15	3.41
100	2.89	3.15	3.41	3.67	3.94
125	3.54	3.81	4.07	4.33	4.59
150	4.20	4.46	4.72	4.99	5.25
175	4.85	5.12	5.38	5.64	5.90
200	5.51	5.77	6.04	6.30	6.56
225	6.17	6.43	6.69	6.95	7.22
250	6.82	7.09	7.35	7.61	7.87
275	7.48	7.74	8.00	8.27	8.53
300	8.14	8.40	8.66	8.92	9.19
325	8.79	9.05	9.32	9.58	9.84
350	9.45	9.71	9.97	10.23	10.50
375	10.10	10.37	10.63	10.89	11.15
400	10.76	11.02	11.28	11.55	11.81

Figure 9. Example calculation for letter height model



Parallel sign letter size can be determined using the following equation, given the number of lanes of travel and the lateral offset of the sign from the curb. The equation uses an average Legibility Index of 10, based on the standards described earlier for perpendicular signs. When using the equations or the lookup table always use the maximum number of lanes on the primary target road.

The USSC Standard for parallel sign letter height should not be interpreted as or applied in a fashion that prohibits other parallel sign and letter sizes that do not comply with the Standard, i.e. signs and letters that do not meet the Standard. The parallel sign and letter size recommended Standard is provided as a guide that can be used when there is a need to determine appropriate parallel sign and letter sizes in a variety of contexts.

Equations and Lookup Table

The following equations can be used to determine appropriate letter heights for parallel mounted signs given the number of lanes of travel and the lateral offset of the sign from the curb. Equation #1 uses an average Legibility Index of 10, while Equation #2 allows users to input the LI that most closely matches their sign conditions from the USSC Legibility Index table (Table 4) and applies the three times threshold constant to that LI. A parallel sign letter height lookup table is also provided for typical roadway cross-sections and lateral sign offsets (Table 7).

When using the equations or the lookup table always use the maximum number of lanes on the primary target road.

Parallel Letter Height Model Equation

Equation #1: LH = (LN x 10 + LO) / 5

where:

LH is letter height in inches.

LN is the number of lanes of traffic.

LO is the lateral offset from curb in feet.

Examples of how to work the equations

2-Lane Roadway

Lateral offset is 37 feet from the curb.

User does not know the letter style.

Equation #1: LH = (LN x 10 + LO) / 5

LH = (2 x 10 + 37) / 5

LH = 57 / 5

LH = 11.4 inches

Same scenario, but user knows the sign is: Externally Illuminated, Helvetica, all Caps, Light Letters on Dark Background

(USSC LI = 22 ft/in)

Equation #2: LH = (LN x 10 + LO) / (LI / 6)

LH = (2 x 10 + 37) / (22 / 6)

LH = 57 / 3.67

LH = 15.5 inches

Table 7. Parallel sign letter height lookup table

	Letter Height in Inches				
	Number of Lanes				
Offset from Curb (ft)	1	2	3	4	5
10	4	6	8	10	12
20	6	8	10	12	14
40	10	12	14	16	18
60	14	16	18	20	22
80	18	20	22	24	26
100	22	24	26	28	30
125	27	29	31	33	35
150	32	34	36	38	40
175	37	39	41	43	45
200	42	44	46	48	50
225	47	49	51	53	55
250	52	54	56	58	60
275	57	59	61	63	65
300	62	64	66	68	70
325	67	69	71	73	75
350	72	74	76	78	80
375	77	79	81	83	85
400	82	84	86	88	90

Sign Illumination

The USSC has completed a series of six (6) on-premise sign lighting studies and reports designed to assist in the understanding of how on-premise signs function at night when illuminated, and to address questions on the best type of lighting at night for the driver and traffic safety – including best lighting level (or luminance) for signs at night, and best type of sign construction. Included in these studies is an examination of:

- □ The environmental impact of on-premise sign lighting
- □ The best type of sign lighting for driver detection & legibility
- □ Whether a real world environment changes detection & legibility results
- □ What lighting level, or brightness, is best at night for driver detection and legibility

Testing has shown that on-premise signs are easier for drivers to (a) see and (b) read during the day. These two concepts are often referred to as "detection" and "legibility". Because drivers can see and read signs best during the daytime, then for purposes of traffic safety, sign illumination practices at night should attempt to get as close as possible to the daytime benchmarks. The functions of on-premise signs are no less critical after dark as they are during daylight hours, and their functional value may be even more critical to the safety and cognitive implications for older drivers, whose visual acuity has been shown to deteriorate markedly at night.

On-premise sign lighting standards also reflect the informational transfer and communication aspects that are unique to the on-premise sign medium, as these signs provide a principal means of roadside communication and situational awareness for drivers, in both form and function. It is this place-based orientation that gives on-premise signs their unique character, but which also acts to limit their communicative ability to a relativity short span of time during which they can be seen by any given driver.

Types of Sign Illumination and Sign Construction

On-premise signs can be illuminated at night using a variety of lighting techniques. There are two principal methods for providing sign lighting - internal illumination and external illumination – and these were the two types of sign lighting studied over the course of the research.

Internal illumination: An internally illuminated on-premise sign has its lighting element or lighting source contained inside the sign cabinet, letter module, or sign body. Typical lighting elements used for internal illumination include fluorescent lighting, neon tubing, and light-emitting diodes (LEDs).

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

A third method of sign lighting is used less frequently, but has the longest history. Exposed lighting elements provide unique character to many on-premise signs, and these applications include exposed neon tubing on signs and letters, incandescent and LED-based exposed lamp bulbs on theater, event signage, and other types of applications. These lighting methods were also studied in several of the research projects.

National electrical and fire safety standards exist regarding the fabrication and installation of internally illuminated signs – see the National Electric Code and testing agencies such as Underwriters Laboratories. By contrast, there are few if any rules regarding the installation of lighting for externally illuminated on-premise signs, the appropriate placement of external lighting fixtures, and the type of lighting required.

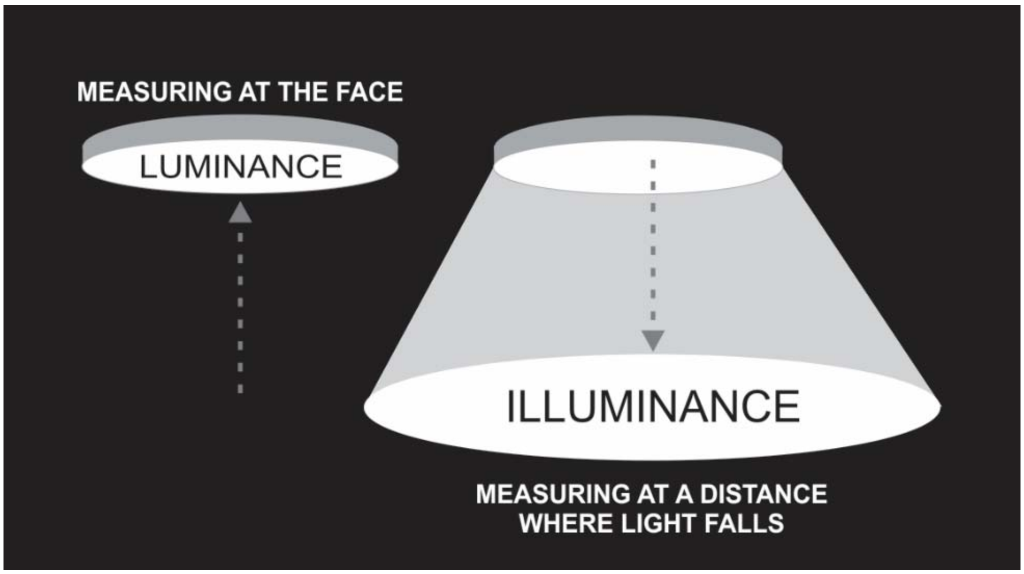
Additional information on sign lighting can be found in *On-Premise Sign Lighting – Terms, Definitions, Measurement,* The Visual Communication Research Institute (2010).

Measuring Sign Brightness: Luminance

There are two accepted ways to consider and measure the light produced by an object or sign. The first is to measure the "brightness" of the sign at the face of the sign, or its "luminance." Luminance measures light output at its source, is a constant, and does not vary with ambient light conditions.

There is a second metric that can be applied to sign lighting, termed "illuminance", which refers to a projection of light from a sign into surrounding space, such as light cast by a sign onto property line or ground surface. Illuminance diminishes rapidly with distance from a sign, and this reduction in light is measurable at any point from the sign at a rate equal to the square of the distance from the sign.

Figure 10. Luminance and Illuminance



These basic lighting concepts can be sometimes hard to understand because there are two sets of photometric terms used to measure and describe them – the SI (or metric) system and English units of measurement. The dual systems can cause confusion, which is significant, because the systems are not aligned in terms of terminology and measurement equations, although one can convert values from one system to the other using formulae.

Luminance: The SI (metric) unit is **candelas per square meter** or cd/m2, and the English unit is **foot lamberts** (or candles per square foot, cd/ft2). One **foot lambert** is equal to 3.43 **candelas per square meter** (cd/m2.) **Candelas per square meter** (cd/m2) is often referred to as a **nit**, which is neither an SI (metric) nor an English term, but is used frequently to describe sign luminance and to measure sign brightness.

Illuminance: The SI (metric) unit is **lux** (lx) and the English unit is **foot candles**. One **foot candle** is equal to ten **lux**. Table 8 provides conversion factors from one system to the other.

Table 8. SI (Metric) and English Conversion

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

The USSC standard for the measurement of on-premise sign illumination is "luminance," based on the needs of the driver and traffic safety. The standard luminance value for on-premise signs at night has been found to provide optimum legibility and reading sight distances for drivers without any significant impact on environmental light trespass or sky glow.

Luminance can further be objectively controlled and measured during the sign design process, the sign fabrication process and after installation in the field to ensure adherence to the luminance requirements of the standard set forth below.

The standard does not restrict sign luminance during daylight operation. Electronic signs and other dynamic message signs which, because their LED powered display surfaces, require daylight illumination of sufficient luminance to maintain legibility under bright ambient light, may require lighting adjustment of their lighting output during the day, in addition to lighting adjustments at night.

Illuminance has only an indirect relevance to on-premise signs. The illuminance that a sign may possess does not relate to the issue of adequate sign brightness for driver detection and legibility. It is a variable lighting measurement dependent on distance from the sign itself.

In addition, since on-premise signs are not designed to cast light on other objects or spaces or provide task lighting, their illuminance only becomes relevant in terms of its possible relationship to an environmental concept called “light trespass.” Because research has shown that internally illuminated signs have low initial light levels that fall off rapidly with distance, internally illuminated on-premise signs have virtually no significant light trespass implications. Light trespass is most likely to occur where there is a problem with badly aimed external sign illumination. Nonetheless, in addition to their other provisions, communities may address the issue of light trespass by requiring that the illuminance of signs be restricted to a specific level at property lines when immediately adjacent to residential properties.

Sign Lighting Levels, Environmental Issues and Energy Conservation

Researchers have investigated the potential consequences of sign lighting design. First, in regard to “sky glow” (sky brightness caused by artificial light reflecting off the atmosphere), it was found that there are no agreed upon-objective methods for physically measuring overall sky glow, and no universally agreed-upon levels of acceptable or unacceptable sky glow. Moreover, there is no metric to measure sky glow from a single light source, like a sign, nor any objective standard or measurement technique to establish the effect of on-premise identification sign lighting on sky glow at this time.

Second, in regard to “light trespass,” researchers found that (a) light trespass is a concept related to sign illuminance (light falling where it is not wanted or intended) and is not related to the needs of the driver or traffic safety; and (b) the illuminance of all sign lighting designs measured in research had a mean vertical illuminance below 3.0 lux (or .3 footcandles) at a reasonable distance from the signs measured, a light level which is not associated with light trespass.

In addition, initiatives involving energy savings achieved through the reduction of sign luminance from optimum levels are likewise not considered appropriate to sign lighting standards because there is the potential that such reductions may compromise traffic safety. Unlike outdoor lighting in the nighttime landscape, on-premise signs are specifically designed to provide vital wayfinding and situational awareness information to drivers, and to this end, must be permitted to maintain illumination levels consistent with optimum legibility and viewer reaction time parameters. The minimum luminance value for standard sign illumination is structured to comply with these parameters.

Communities historically have had concerns about on-premise sign lighting on properties that are adjacent to residential areas. The USSC sign illumination guideline standards provide a baseline for setting brightness levels for all on-premise signs; adjustments for local circumstances may be made by individual local jurisdictions accordingly.

Best Sign Lighting Method for the Driver

Extensive sign illumination research, conducted under both test track and real world conditions, has shown a marked difference in sign detection and sign legibility between internally illuminated signs and externally illuminated signs.

Legibility: The difference in legibility between internal and external sign illumination has been calculated to provide as much as a 70% advantage in legibility favoring internal over external sign lighting. Since sign lighting and traffic safety are inextricably intertwined, the use of internally illuminated signs should neither be prohibited nor curtailed in any zone or district where vehicular traffic is present.

Distance: Research has shown conclusively that internally illuminated on-premise signs are read from a much greater distance than externally illuminated signs. This was first demonstrated in test track research, where 40 to 60 percent longer reading distances were found with internally illuminated signs. In subsequent real world studies directly comparing internal and external illumination, the results confirmed that when externally illuminated signs are switched to identical signs using internal illumination, drivers on average read the internally illuminated signs more rapidly and at a greater viewing distance.

Time: In a majority of cases, externally illuminated signs did not afford the driver adequate time to detect and read the sign, and execute a driving maneuver. Internally illuminated signs gave drivers on average an additional 2 seconds more time than externally illuminated signs to read the signs and execute a driving maneuver. Or, to illustrate the condition another way, in comparing the time to read a sign between internal and external illumination, an externally illuminated sign must be increased in size by 40% over the size of an internally illuminated sign, to achieve the same legibility factor, or the speed of traffic must be reduced by 40% to achieve the same legibility values, internal vs external illumination.

In any driving environment where posted speeds are at 25 MPH or higher, on-premise signs provide motorists with wayfinding and situational awareness information, and the time required to process that information is critical. These research findings in regard to sign illumination have significant traffic safety implications.

On-Premise Sign Illumination Guideline Standard

The USSC has established a sign illumination guideline standard for on-premise signs at night based on the results of completed research. This standard insures that sign lighting can meet the needs of the driver in regard to on-premise sign detection and legibility.

The USSC standard is based on the luminance of a sign. As discussed above, luminance is the measurement of the brightness of a sign at its face. Testing has provided maximum luminance levels for optimum sign detection and legibility. This guideline standard does not dictate that all signs should meet a certain luminance level at all times; rather, it sets the outer-most level for signs, beyond which on-premise sign brightness should not extend. In that regard, signs with luminance values greater than the standard did not perform better in sign legibility testing. Therefore, increasing sign brightness beyond the standard does not yield better sign legibility, and is not recommended in these guidelines. The vast majority of on-premise signs, using different color combinations and designs, will have luminance values far below the maximum standard for brightness at night.

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

The USSC Sign Illumination Guideline Standard: It is recommended that all illuminated signs comply with the maximum luminance level of seven hundred fifty (750) cd/m² or Nits at least one-half hour before apparent sunset, as determined by the National Oceanic and Atmospheric Administration (NOAA), US Department of Commerce, for the specific geographic location and date. It is also recommended that all illuminated signs comply with this maximum luminance level throughout the night, if the sign is energized, until apparent sunrise, as determined by the NOAA, at which time the sign may resume luminance levels appropriate for daylight conditions, when required or appropriate.

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