USSC

STANDARDS

ON-PREMISE SIGNS

Research Based Approach To:

Sign Size
Sign Legibility
Sign Height

UNITED
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USSC BEST PRACTICES GUIDELINE STANDARDS

On Premise Signs

United States Sign Council
Best Practices Standards

A Research Based Approach To:

- Sign Size
- Sign Legibility
- Sign Height

Perpendicular (head-on view) configuration

Parallel (side view) configuration

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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.

Five distinct volumes comprise the collaborative work of the United States Sign Council and the research and engineering associates of the Pennsylvania Transportation Institute:

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) ON PREMISE SIGNS, Determination of Parallel Sign Legibility and Letter Heights (2006)

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

How Motorists React To Signs In The Roadside Environment

Detecting and reading a roadside on-premise sign by a motorist involves a complex series of sequentially occurring events, both mental and physical. They include message detection and processing, intervals of eye and/or head movement alternating between the sign and the road environment, and finally, active maneuvering of the vehicle (such as lane changes, deceleration, and turning into a destination) as required in response to the stimulus provided by the sign.

Complicating this process is the dynamic of the viewing task, itself, involving the detection of a sign through the relatively constricted view provided by the windshield of a rapidly moving vehicle, with the distance between the motorist 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, and at 60 miles per hour, it becomes an impressive 88 feet per second. Further complicating the process is the relative position of the sign to the eye of the motorist, whether directly in his/her field of view (perpendicular orientation), or off to the side and turned essentially parallel to the motorist's field of view (parallel orientation).

Research has now been able to quantify the viewing process and set a viewing time frame or viewing window of opportunity for both types of sign orientation. In the case of signs perpendicular to the motorist, this time frame is measured as Viewer Reaction Time (VRT), or the time frame necessary for a motorist traveling at a specific rate of speed to detect, read, and react to a sign within his/her direct field of vision with an appropriate driving maneuver. The driving maneuver itself can entail a number of mental and physical reactions, usually involving signaling, lane changes, acceleration and/or deceleration, and finally, a turn into the site of the sign.

In the case of signs parallel to the motorist's view, detecting and reading a sign is generally restricted to quick sideways glances as the sign is approached and the angle of view becomes more constricted. Because of this, the VRT involving these signs is, at best, necessarily compromised. Compensation for this reduction in the time frame involved in detecting and reading parallel signs is made through increases in letter height and size designed to facilitate rapid glance legibility. It must be understood however, that the parallel orientation will always present legibility problems, and in many cases, even if the sign is detected and read, sufficient time for a motorist to complete a driving maneuver in response to the sign may not be available.

PERPENDICULAR SIGNS

DETERMINING SIGN SIZE – The Component Determinants

Within the viewing process, the 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.

<u>Viewer Reaction Time</u>

<u>The Viewing/Reaction Process</u>

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.

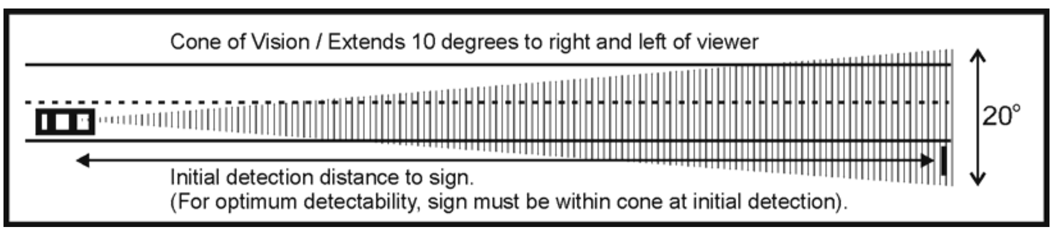


Figure 1. Cone of Vision and Detectability

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

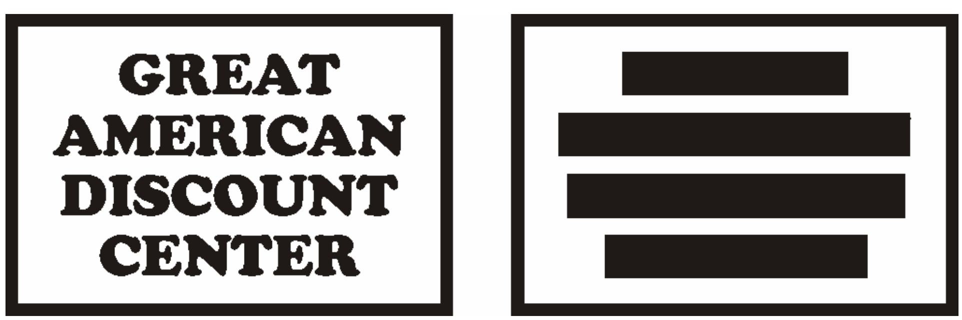
Apply Adjustment Factor of 0.67

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

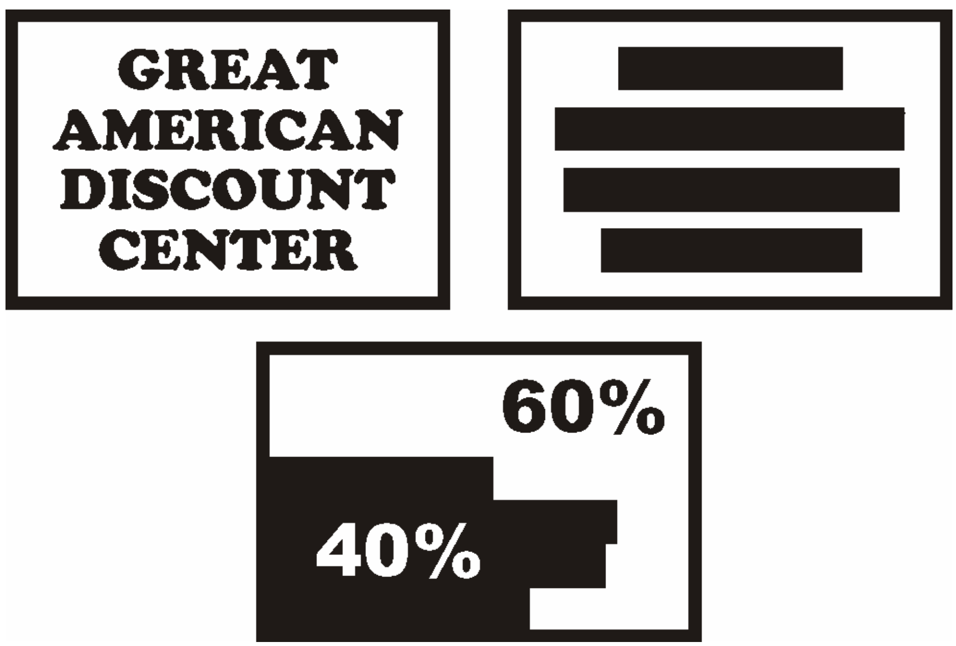


The illustration on the left depicts a typical on-premise sign face; while the one on the right, with black rectangles covering the copy area, affords a visual of the message layout

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 ideally should not be less than 60 percent of the sign or background area. 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 Sign 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 sign 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.

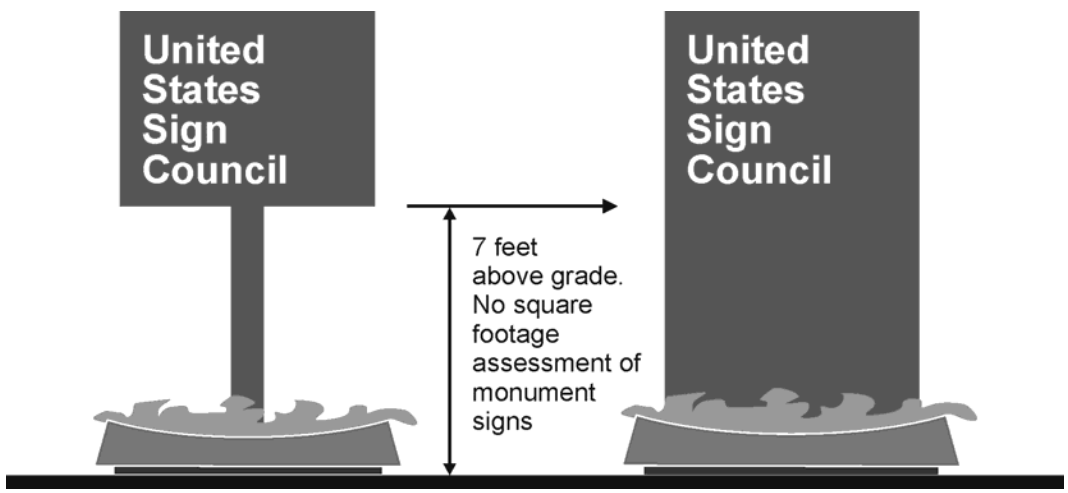
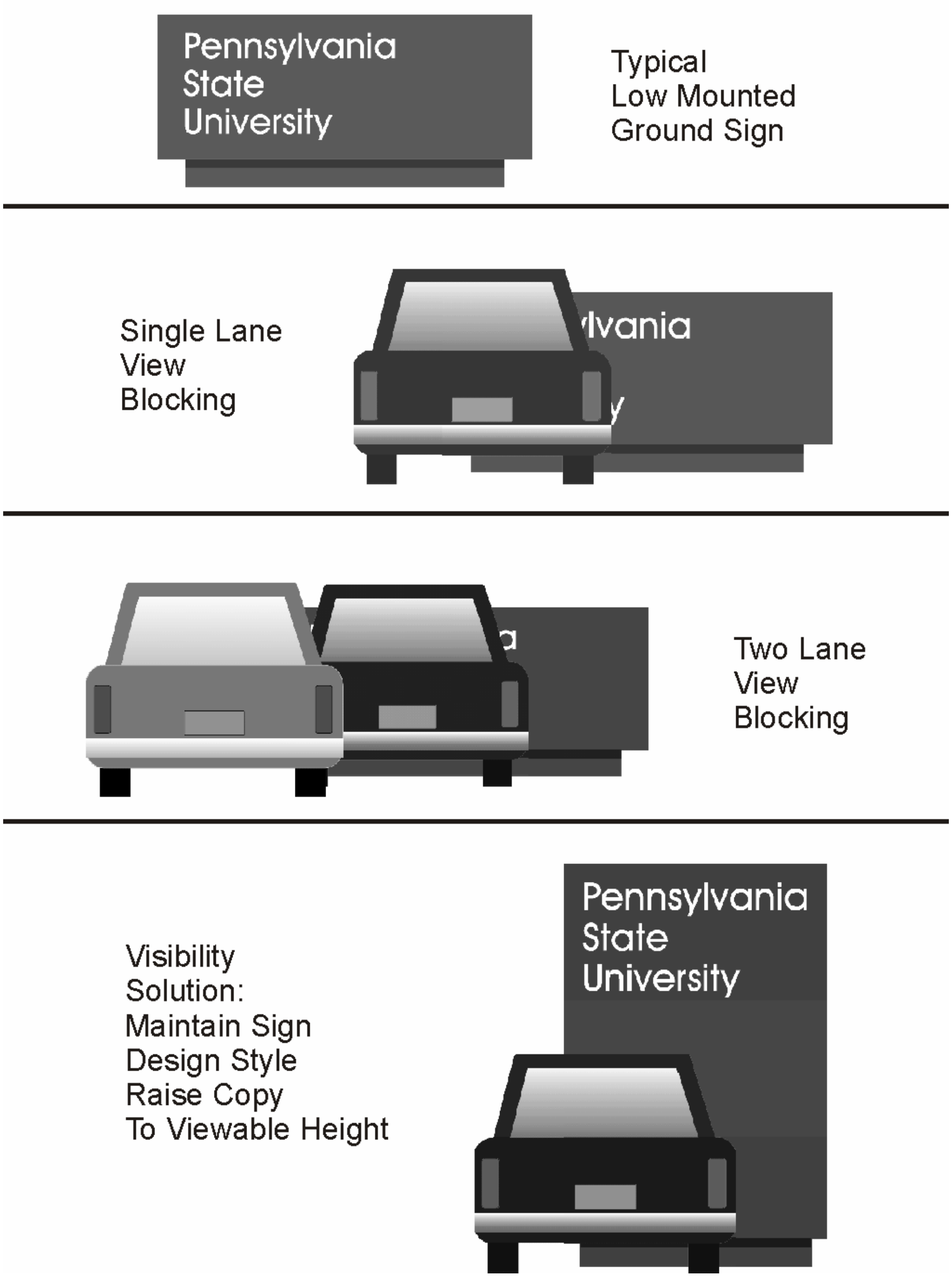


Figure 6. Comparison / Pole and Monument Signs

Sign Blocking Scenarios (Schematic)

Sign Blocking Charts (Schematic)
Blocking Tables

Sign Blocking Scenarios (Schematic)



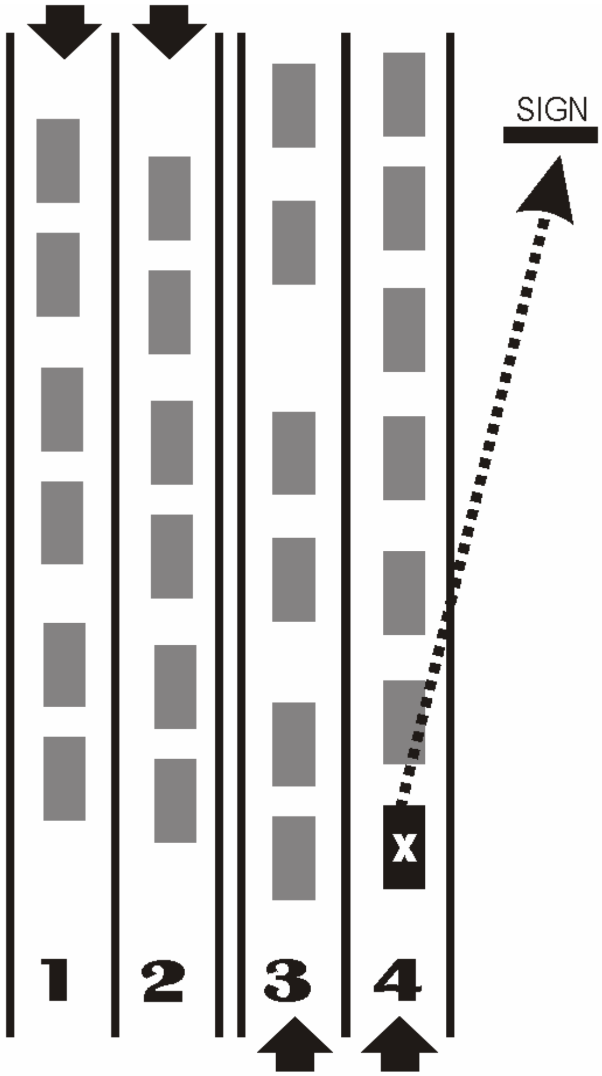


Chart A

(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

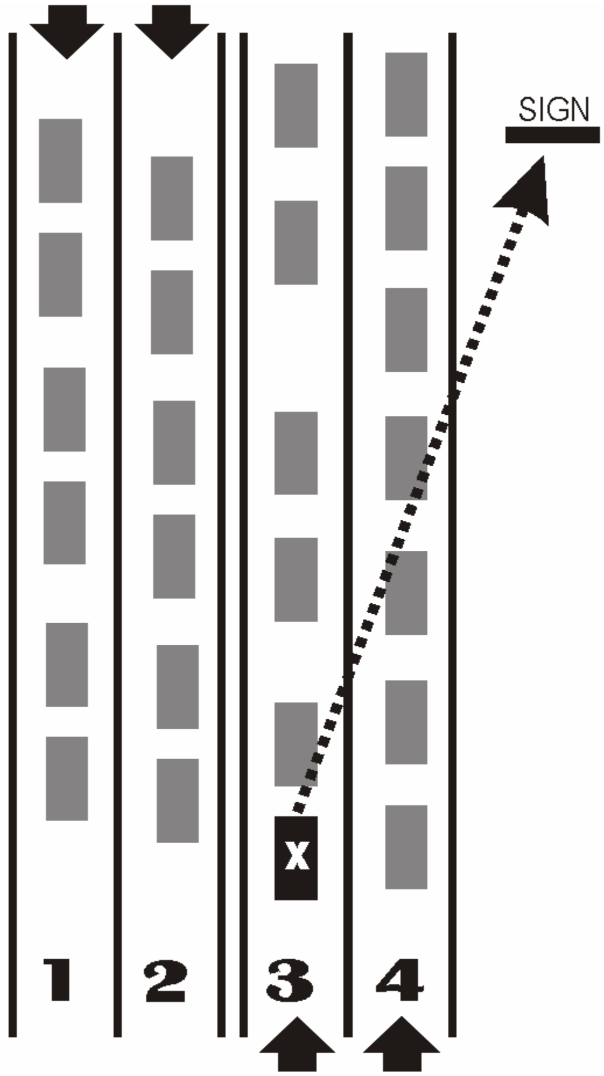


Chart B

(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

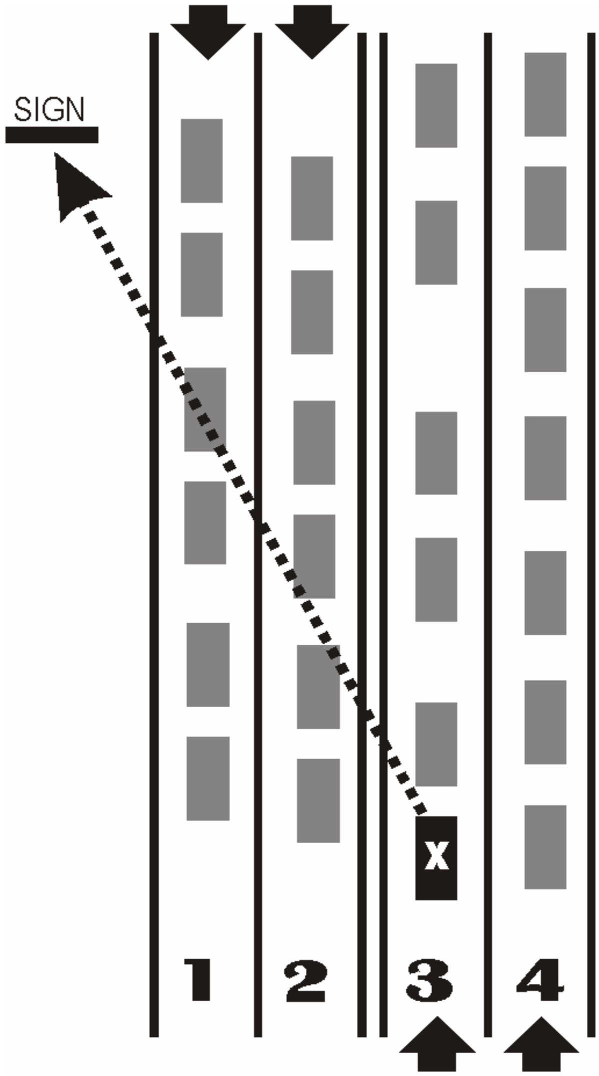


Chart C

(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

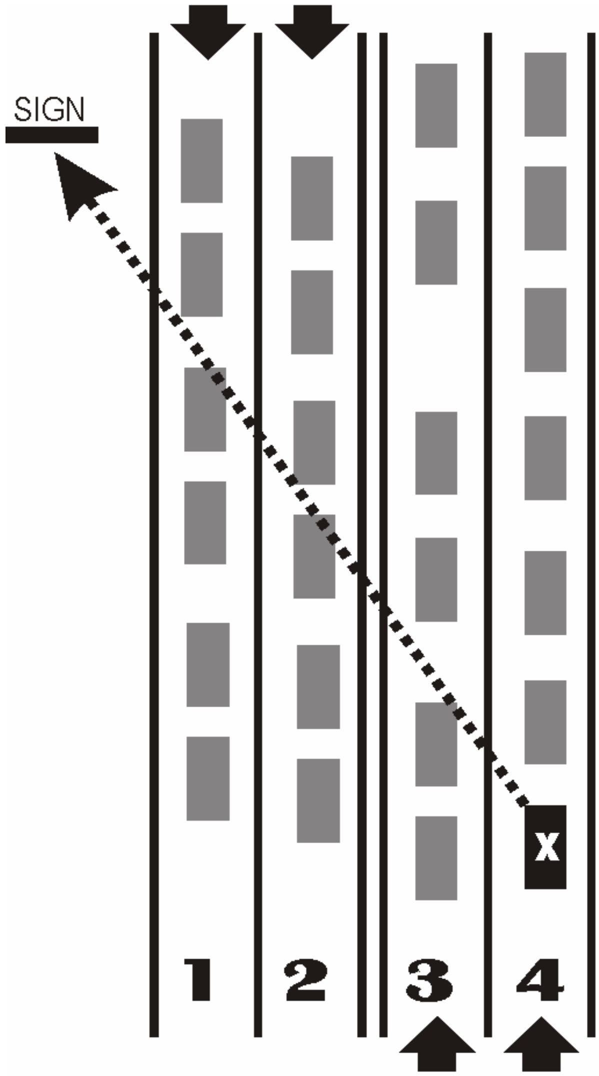


Chart D

(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

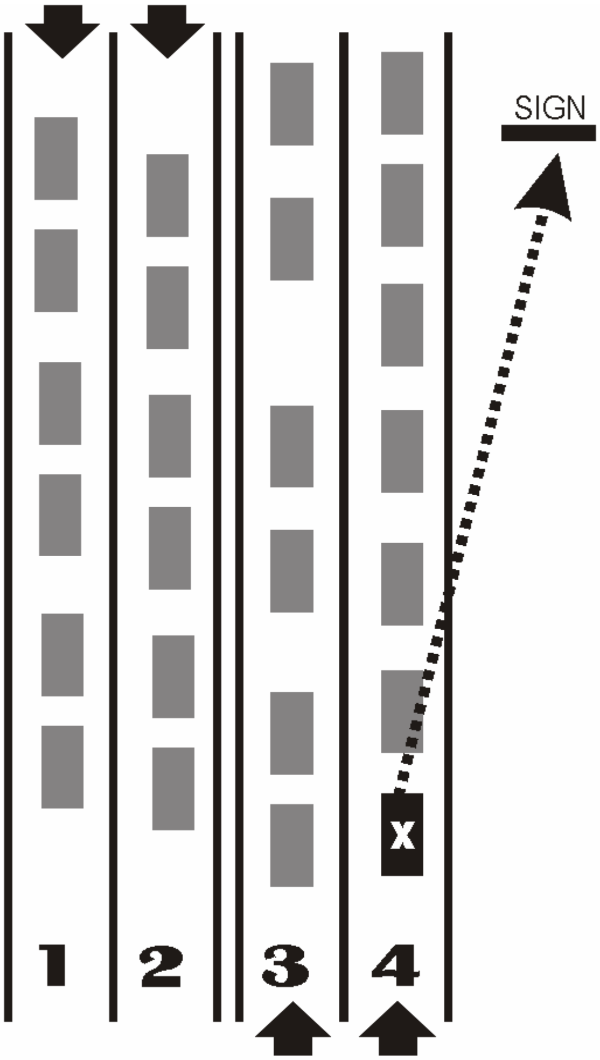


Chart E

(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

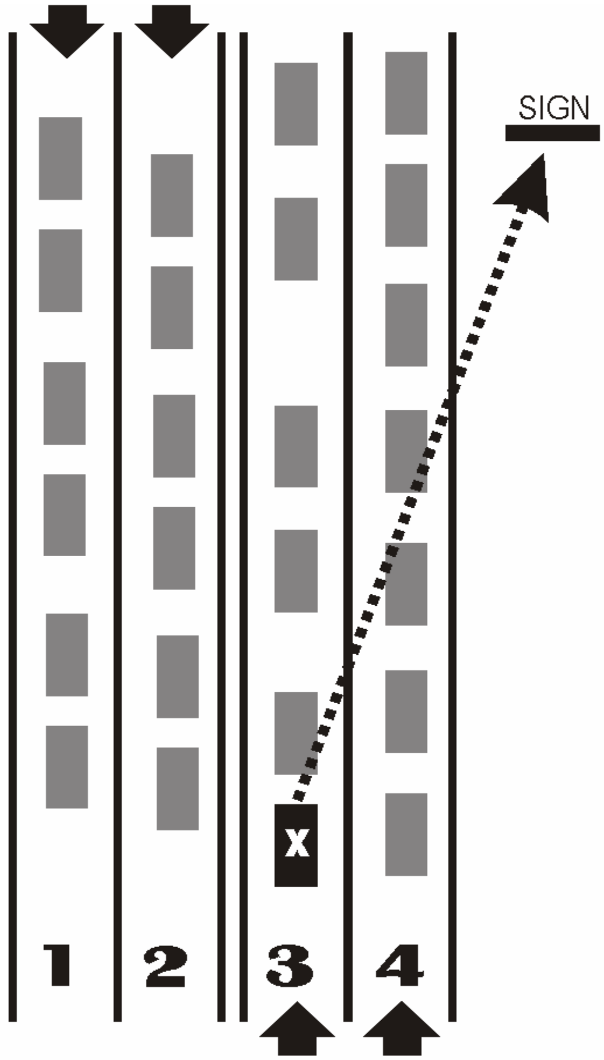


Chart F

(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

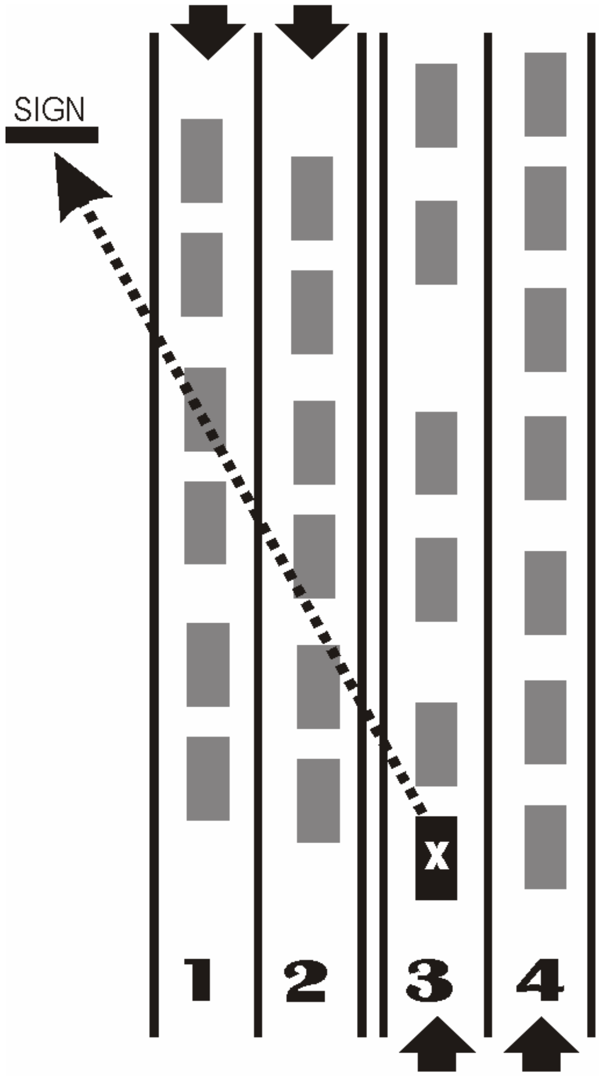


Chart G

(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

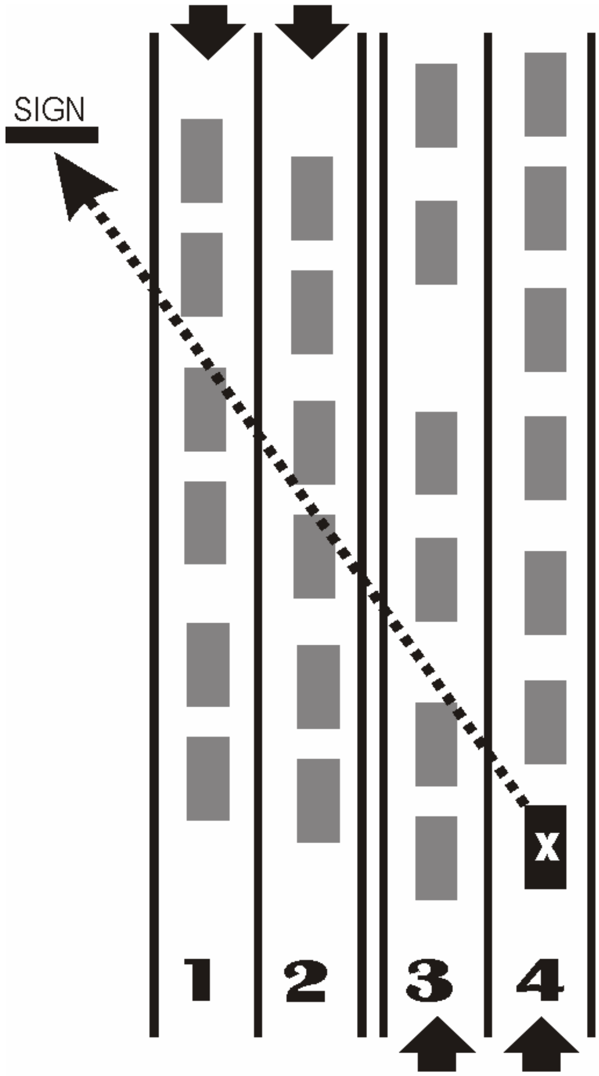


Chart H

(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

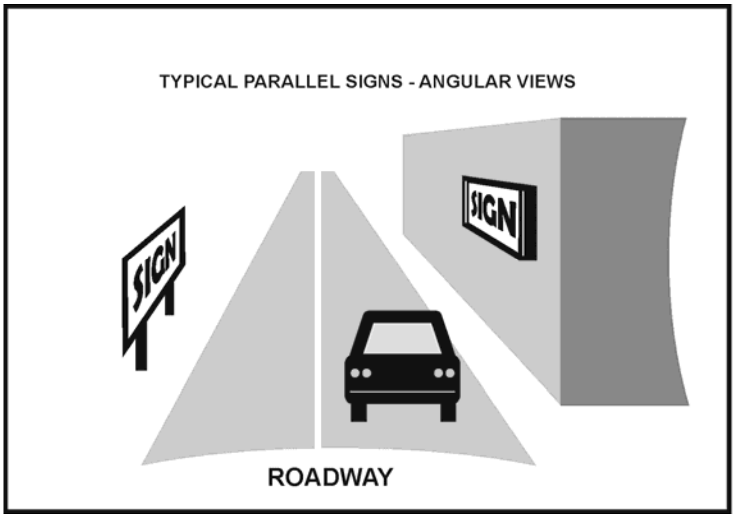


Figure 7. Parallel Sign Types

Everyday experience teaches us that parallel signs are more difficult to read than perpendicular signs simply because their orientation to the eye of any observer is at an acute angle. Now USSC research has corroborated this subjective impression with scientific evidence, and has made it possible to construct a mathematical model and attendant equations to account for the size increases necessary to allow parallel oriented signs to achieve at least some measure of the legibility quotient of perpendicular signs in a motorist oriented environment.

Parallel signs are harder to read because their orientation, or tilt, with respect to the driver makes it impossible to see the sign face at certain distances and offsets. When the driver can see the sign face, the content is often foreshortened and distorted. The driver must get close to the sign in order to increase the viewing angle to the point where the sign becomes legible. However, as drivers approach the sign, the time they have to read it gets shorter, while the sign moves further into their peripheral vision.

This condition places parallel signs at a threefold disadvantage relative to perpendicular signs. First, they are inherently more difficult to read because of the foreshortening of the message content caused by the angle of view. Second, because they become legible only after the angle of view exceeds 30 degrees, the time frame during which legibility can take place is compressed, and third, because they are usually placed back from the roadside well outside a driver's cone of vision, they are viewed by drivers only during short sideway glance durations, usually measured in fractions of seconds (see Table 6).

In many cases, their orientation causes not only severely compromised legibility compared to perpendicular signs, but results in the sign not being seen at all. In the USSC study, *Real World On-Premise Sign Visibility,* in which people were asked to drive through typical suburban shopping areas and locate specific signs, perpendicular signs were almost never missed while the subjects drove past 30 percent of the parallel signs, even though the parallel signs were two and three times larger than the perpendicular signs and the drivers were actively looking for them.

Parallel signs, therefore, must be read using a series of very quick glances at large visual angles during small windows of opportunity. Because of this, letter heights developed for perpendicular signs, where drivers have more time and can take longer straight ahead glances, cannot provide for adequate parallel sign legibility.

As we have noted in the case of perpendicular signs, the minimum distance at which a sign must become legible is a function of the time it takes to read the sign and the decisions and maneuvers required to comply with the sign. This is the Viewer Reaction time (VRT), which when combined with the speed of travel, becomes the Viewer Reaction Distance (VRD). Given the VRD, a perpendicular sign's letter height can be calculated using the Legibility Index.

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

25 mph Speed Limit					
	Number of Lanes				
Offset from Curb	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					
	Number of Lanes				
Offset from Curb	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

The legibility of parallel signs, however, depends not on a driver's line of sight to a sign down the road, but rather when the sign becomes visible to the driver at a sight angle sufficient to allow at least some glance legibility to take place. A significant amount of research has now determined that this angle should be no less than 30 degrees to the driver's line of sight, and it is the visual restriction imposed by this angle, along with the number of lanes of travel, and the sign's offset from the curb, which determines the Maximum Available Legibility Distance, (or MALD) for a given parallel sign

While traversing this distance, however, a driver cannot be expected to register much more than a few quick glances at the sign without adversely affecting his/her view of the road. Thus it is essential to optimize reading speed for parallel signs in order to minimize the duration and frequency of glances that drivers must make to read the sign. Research has shown that reading speed increases to its maximum as letters are enlarged by a factor of three, and then tends to level off; and to ensure adequate letter height for parallel signs, a multiplier of three is used in the mathematical model to determine the letter heights and the legibility index for parallel signs.

Using this multiplier of three as a benchmark or rule of thumb, the Legibility Index for parallel signs falls to 10, instead of the Legibility Index of 30 we have shown as a rule of thumb for perpendicular signs. Thus a parallel sign with a MALD of 500 feet, for example, would require a capital letter size of 50" (500/10=50). Conversely, a perpendicular sign at the same location, but directly viewable 500 feet down the road, would require a capital letter size of 17" (500/30=17)

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 LI 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 Equations

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

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

where:

LH is letter height in inches.

LN is the number of lanes of traffic.

LO is the lateral offset from curb in feet.

LI is the legibility index from Table 1

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

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