

 Ontario

**Book
1B**

**Ontario
Traffic
Manual**

July 2001

Introduction to the Ontario Traffic Manual

Appendix B - Sign Design Principles

COLLECTOR MOVING WELL
BEYOND NEXT TRANSFER

DETOUR

Emily
Street

EXIT

NEW

m/h

TAXI

STOP

THIS
LANE

400

ONTARIO

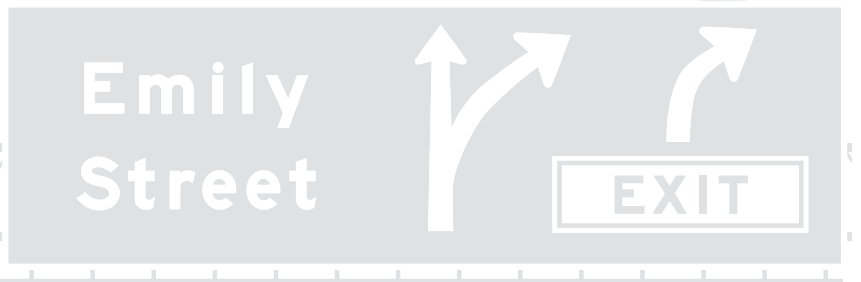
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Introduction to the Ontario Traffic Manual

Appendix B - Sign Design Principles

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1. Introduction

1.1 Purpose

A consistently applied set of sign design principles is necessary to facilitate driver understanding of, and response to, sign messages. For the sign design principles to be effective, they must realistically be based on the visual and mental abilities of road users.

Book 1b (Sign Design Principles) of the Ontario Traffic Manual (OTM) is intended to assist OTM users in understanding sign design principles and related driver requirements. This knowledge will enable OTM users to:

- Understand the design of existing signs in the OTM;
- Design new local directional guide signs and other information signs;
- Use the appropriate size of sign for a given application;
- Use the appropriate sheeting material and level of illumination for a given application;
- Mount each sign in an appropriate location;
- Institute operational programs to ensure the ongoing effectiveness of signage.

In outlining general sign design principles, Book 1b reflects sign design principles applied currently in Ontario, by the Ministry of Transportation of Ontario (MTO) and municipalities, that are considered to be good practice.

1.2 Standardization of Design

High travel speeds and increasingly complex driving environments require that signs be readily detected and understood at a glance. Uniformity and simplicity in design, position and application are crucial for speedy detection and recognition. It is therefore important that sign design principles be consistently applied, and that signs installed on highways conform to the designs and standards represented in the Ontario Traffic Manual.

Uniformity in design includes sign shape, colour, dimensions, symbols, wording, lettering and reflectorization or illumination. Many of the sign designs in the Ontario Traffic Manual have been approved by the National Committee on Uniform Traffic Control Devices for Canada after a thorough review of various designs used in Canada, supplemented by test studies.

Sign patterns for standard OTM signs are provided in Book 2 (Sign Patterns and Fabrication). All sign shapes and colours must be used as indicated in OTM Book 2. In addition, all symbols must be the same as those shown in Book 2, and wording on signs containing text must be as indicated.

Uniformity of application is also an important element of standardization. Similar conditions should be signed in the same manner, regardless of actual location. It is recognized, however, that urban conditions differ from rural conditions with respect to speed, frequency of intersections, traffic congestion, parking and competing lights and displays. Where such differences in the driver environment impact the sign message, sign application must take into account these differences. Where practical, the OTM presents separate guidelines for rural and urban areas.

2. Driver Requirements

Sign design must take into account driver limitations in detecting signs in the roadway environment, processing the sign information, and selecting an appropriate response. Driver limitations determine requirements for letter size, the selection of font, contrast, retroreflectivity, spacing and borders, message layout and reading time, as well as sign spacing and placement. The more a sign meets driver needs, the more likely a driver will detect it, the more likely he or she will be able to read and understand the message, and the more likely he or she is to select the response desired by the traffic practitioner.

Traditional sign design does not explicitly consider these driver needs. In particular, no allowance is made for the fact that longer messages require more time and therefore greater legibility distance. Nor is sufficient distinction made, in terms of sign placement, between signs requiring the driver to make one of several choices and then complete a manoeuvre, as compared to signs that are “information only”. Instead, a particular distance is assumed, depending mainly on speed, and letter height is determined through an assumed driver reading ability of some number of metres legibility per centimetre of letter height. In the past this assumed driver reading ability has been 6 m legibility per centimetre of letter height (50 feet legibility per inch letter height), which does not encompass the majority of drivers, and assumes almost double the actual legibility distance of drivers with 20/40 vision, licensable under MTO regulations.

Several criteria must be met for a sign to be effective. Initially, it must command attention or be easily detected by the person who needs the information (i.e., it must have good conspicuity). It must be legible at the appropriate distance (in time

to read the whole message and take the necessary action). At busy urban locations, signs, traffic signals and markings can easily be hidden by large vehicles and seen only briefly. Therefore signs should be readable quickly, as drivers often have only a second or two to interpret and respond to the message. The message must obviously be understandable, otherwise the user will not know whether or how to respond to it. If the meaning of the message (e.g., a new symbol) is not immediately understood, driver error or delay can easily result.

Other, perhaps less obvious, criteria are that the information on the sign should be easily rejected if it is irrelevant for the driver, and that the action to be taken in response to the message should be immediately obvious. Drivers often are in situations where there is a great deal of information from the roadway environment (not only signs). It may not be possible to attend to and process fully all of this information. The driver must be able to glance at the sign and determine rapidly whether the information is relevant and should be processed, retained and acted upon. As all signs are possible sources of relevant information, the driver must first take in and process the information at a superficial level before it can be decided whether it is relevant. This takes mental effort and time, which the driver may not have under conditions of input overload and stress. The appropriate action should not require a significant amount of thinking and decision time, especially if the action involves a manoeuvre which must be taken quickly (e.g., change lanes to exit or to avoid exiting ahead).

Finally, signs are most likely to be obeyed when they appear to be reasonable to the driver, and when they augment the roadway message rather than contradict it. For example, the use of speed signs to lower speed, in the absence of changes in the roadway, is likely to be ineffective.

Table 1 – Shape and Colour Codes for Signs







Class	Sub-Class	Shape Code	Colour Code			Comments
			Back-Ground	Message	Border	
R Regulatory	Ra Right of Way Control		Red	White	White	Shape reserved for STOP sign
R Regulatory	Ra Right of Way Control		White	Red	Red	Shape reserved for YIELD sign
R Regulatory	Ra Right of Way Control		White	Black	Black	Various Pedestrian Right of Way Control Signs
R Regulatory	Rb Road Use Control		White	Black	Black	A green annular band shall indicate a permissive message A red annular band with interdictory stroke shall indicate a prohibitive message
R Regulatory	Rb Road Use Control		White Black	Black White	Black White	A green annular band shall indicate a permissive message A red annular band with interdictory stroke shall indicate a prohibitive message
R Regulatory	Rb Road Use Control		Blue	White	White	Reserved for School Area Signs

Table 1 – Shape and Colour Codes for Signs (cont'd)


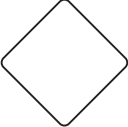
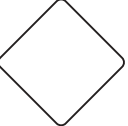
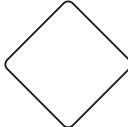

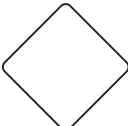







Class	Sub-Class	Shape Code	Colour Code			Comments
			Back-Ground	Message	Border	
R Regulatory	Rc Miscellaneous Control Signs		White	Black	Black	
W Warning	Wa Physical Conditions		Yellow	Black	Black	
W Warning	Wb Traffic Regulations Ahead		Yellow	Black	Black	Some messages contain other colours to adequately represent symbols
W Warning	Wc Intermittent Moving Hazards		Yellow	Black	Black	
W Warning	Wc Intermittent Moving Hazards		Blue	White	White	Reserved for School Area Signs
Tc Temporary Conditions			Orange	Black	Black	

Table 1 – Shape and Colour Codes for Signs (cont'd)

Class	Sub-Class	Shape Code	Colour Code			Comments
			Back-Ground	Message	Border	
Information	G Guide Signs		Green Blue White	White White Black	White White Black	Some signs in this group may contain minor elements of other colours
Information	G Guide Signs		Green White	White Black	White Black	
Information	G Guide Signs		Black	White	White	Some signs in this group have a brown background; or a white background with a blue message and blue border
Information	M Highway Markers		Black Green Brown	White White White	White White White	Some signs in this group may contain minor elements of other colours
Information	M Highway Markers		Black Green	White White	White White	
Tab Signs ALL Classes	ALL Sub-Classes	 	Colours on tab signs to be the same as on primary sign			

In summary, the effectiveness of highway signs depends on several factors:

- **Conspicuity** – does the sign attract attention given the background in which it is placed;
- **Legibility** – at what distance can drivers read the sign;
- **Information load** – do drivers have sufficient time to read the entire message;
- **Comprehension** – do drivers understand the meaning of the message, and any symbols or abbreviations used;
- **Driver response** – do drivers make the desired action as a result of reading the sign.

3. Shape and Colour Codes

Signs that are similar in function are typically designed to be the same shape and to use the same colour combinations for legends, backgrounds and borders. Shape and colour codes serve to organize pieces of information into larger units and establish message redundancy. Drivers can recognize sign shapes and colours well before they can distinguish symbols or read sign text. The shape and colour codes alert the driver to the general function of the sign. They simplify the driving task by enabling the road user to judge in advance the nature of the expected response and to prepare accordingly. For example, drivers can recognize the shape and colour of the STOP sign before they can actually read the sign text. In fact, the STOP sign is one case where the shape and colour convention has made the sign so familiar to drivers that actually reading the text has become unnecessary.

All signs in the OTM have been allocated to classes and sub-classes, according to the specific function of the sign. For example, Class R represents regulatory signs, which regulate the flow of traffic by instructing drivers on what they must or should do. Sub-class Ra, within Class R, refers to right-of-way control signs, which regulate the right-of-way of vehicles and other users at locations where their movements may otherwise be in conflict.

Unique sign shape and colour codes have been assigned to each sign class, with further shape and colour distinctions provided for some sub-classes, and in some cases even within the sub-class. For

example, Class R regulatory signs are generally rectangular in shape and have white backgrounds with black legends. Sub-class Ra signs include some signs with shape and colour codes that follow the general rule for Class R, but also some special signs, such as the STOP sign and YIELD sign, which have their own unique shape and colour codes. Shape and colour codes for sign classes and sub-classes are illustrated in Table 1.

Clearly, shape and colour codes are a powerful element of sign design. Therefore, all signs must follow the shape and colour codes indicated in the OTM. Precise sign shapes are specified in OTM Book 2 (Sign Patterns and Fabrication). Sign colours must be according to the ASTM (American Society for Testing and Materials) Specification D 4956-95 (or its subsequent revisions), typically used by manufacturers of signs and sign sheeting materials. A similar specification available in Canada is the CGSB (Canadian General Standards Board) Specification 62-GP-11M.

To ensure immediate recognition of signs, it is important that the correct shades of the colours are used. Also signs required at night should retain the same colour by night as by day through use of retroreflective sheeting or internal or external illumination (see Section 9). Signs discolour with age, due to ultraviolet radiation and deterioration of retroreflective sheeting. To alleviate discolouration from these causes, regular programs for sign maintenance, inspection and inventory are recommended (see Section 15).

4. Hierarchy of Signs

While all signs that are posted should be necessary, some signs are more critical to drivers than others. A sign can be deemed to be more critical than another sign if failure to read it in time has more serious safety implications than for the other sign. Signs that are more critical from a safety standpoint have been mandated to have high intensity sheeting as of a prescribed date. A suggested overall hierarchy for sign criticalness is provided below. Sign groups are listed in order from most critical to least critical.

- (1) **Signs required to have high intensity sheeting as of a prescribed date:**
 - (a) **Temporary Conditions Signs** (Book 7)
(These are highest priority. The requirement for high intensity sheeting means that these signs are important. Temporary condition signs take priority over other signs requiring high intensity sheeting because of the unexpected situations drivers may encounter, and also because temporary conditions sign placement may be more critical than for other signs.)
 - (b) **Regulatory Signs** (Book 5)
 - (c) **Warning Signs** (Book 6)
(Note: The reference to a prescribed date does not affect the priority of this group of sign; that is, whether or not the signs already have high intensity sheeting, they still retain their priority over signs in the other groups.)
- (2) **Other Temporary Conditions Signs**
(Book 7)

- (3) **Other Regulatory Signs** (Book 5)
- (4) **Other Warning Signs** (Book 6)
- (5) **Information Signs:**
 - (a) **Directional Guide Signs** (Book 8)
 - (b) **Emergency Services Signs** (Book 9)
(give directions to hospitals providing emergency services and law enforcement offices, and recommend radio frequencies for severe weather advisories)
 - (c) **Motorist Services Signs** (Book 9)
(give directions to gas, food and lodging establishments, public telephones and travel information centres)
 - (d) **Public Transportation Signs** (Book 9)
(give directions to rail transit stations, bus terminals and airports)
 - (e) **Boundary Signs** (Book 8)
(mark municipal, regional and county boundary lines)
 - (f) **Attraction Signs** (Book 9)
(identify and direct motorists to special points of interest meeting certain criteria, e.g., provincial and national parks, tourist attractions, historic sites, museums, special commercial attractions, campgrounds)
 - (g) **General Information Signs** (Book 8)
(identify lakes, rivers and other items of general interest).

Sign hierarchy can be used in prioritizing sign improvements with regard to size, level of retroreflective sheeting, new fonts, and other features which may be implemented to more successfully meet driver requirements. Also, some signs low in the hierarchy, such as tourism signs, may be so large as to distract from more important signs higher in the hierarchy, which are smaller. Consequently, the sign hierarchy must be considered in effectively spacing more critical and less critical signs (see Book 1, Section 7 for more information on sign function and interference).

5. Text Legends

Many of the signs in the OTM are text-based, as it is difficult to convey certain complex messages clearly using symbols. In determining the text to be used on a sign, font type, letter height and the use of upper case versus mixed case letters must be considered.

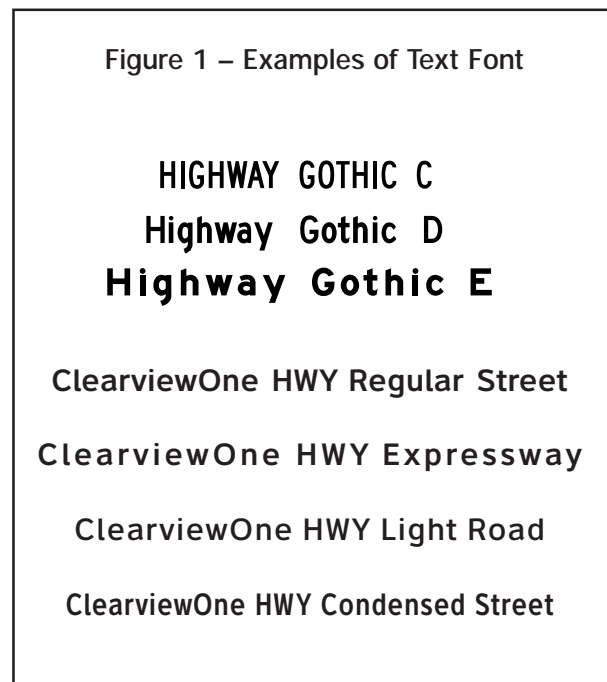
5.1 Font Type

The font type determines not only the appearance of the letters, but the ratio of letter height to letter width, stroke width of the letter relative to letter height, the kerning or space between letters and the spacing between words. Many of the standard fonts currently used for sign texts in the OTM are from the Highway Gothic series of fonts. Three series are commonly used for signs: Series C, D and E(modified) or E(M) (see Figure 1). (Note: For a limited number of signs, several other fonts have been used, such as Helvetica Medium, Helvetica Bold Condensed, Interstate, Century Schoolbook Bold and Century Bold. Because they are in relatively limited use, they are not addressed in the discussion below.)

The letter width to letter height ratio, the stroke width to letter height ratio and the spacing between letters all increase as the font series progresses from C to E(M). For letters of equal height, a number of studies have shown that Series E(M) letters are significantly more legible than Series C or Series D letters of the same height. Series C and D fonts are typically used for regulatory signs, which are quite familiar to drivers and are often easily recognized by their shape and colour codes, while Series E(M) is used for directional guide signs, which have unique messages and rely for effectiveness on whether or not they can be easily read.

Recently, a new font called Clearview (see Figure 1) was developed for traffic signs. It has been shown to be significantly more legible at night than even the Series E(M) font. Because of the increased openness of Clearview characters, its spacing is smaller than that of the standard highway fonts. Words in Clearview font take up 12% less sign space than words in Series E(M) font, but provide exactly the same legibility. When Clearview font spacing is increased to 112%, the letters occupy the same sign space as Series E(M) font, while providing improved legibility at night for older drivers aged 65 and up by 16% to 22%, in comparison to Series E(M) font. (Daytime legibility relative to Series E(M) font is not changed by using Clearview font.)

As noted, the Clearview font offers improved legibility. This font is currently being reviewed by the Ministry for its potential application to replace Highway Gothic fonts on new and replacement directional guide signs.



5.2 Letter Height

In order for a sign to be effective, it must be legible at a distance which allows a driver to read it and carry out any required actions before reaching the sign. When the message is lengthy (e.g., several destination names, or complex construction information), drivers will need more time to read the entire message than for a sign with a single symbol or a word or two. In addition, if the driver must carry out some action, such as a lane change or a stop before reaching the sign, then it must be legible at a distance that allows the driver both to read it and respond before reaching the sign. One of the key factors in ensuring sign legibility at the required distance is the letter height. For details on calculating letter height, see Section 7 (Calculating Letter Height and Symbol Size).

5.3 Upper/Mixed Case

In terms of legibility, mixed case text is better than upper case text, as long as the maximum height of the lower case letters is the same as the height of the upper case capitals. Words in mixed case are easier to recognize since each word forms a distinctive shape with a unique pattern of ascenders, descenders, dots and other features. Word shape pattern recognition enables the driver to identify a word before it can actually be read. While this is a distinct benefit of mixed case over upper case lettering, it must be traded off against motorist familiarity with signs that have been in upper case for many years.

Signs in most of the sign classes have traditionally used upper case letters. For most signs, it is desirable from the standpoint of driver familiarity and uniformity to maintain consistency with existing sign standards. However, in the case of directional guide signs, other information signs and new sign series, mixed case should be used to support improved word recognition. Cardinal directions on information signs (e.g., north, west) may be shown in upper case when used in a mixed case context, to draw attention to the word and to make the word function almost as a symbol.

5.4 Horizontal Reduction

When a sign message does not fit onto a sign blank, there is a tendency to squeeze the width of the letters until the message fits. This type of horizontal reduction reduces legibility. The length of a word should be reduced by no more than 10% to make a message fit onto a given blank size.

6. Symbolic Legends

Symbols can convey in a single image the same message that may require several words of text. Therefore the symbol size is generally considerably larger than individual letters, making the sign legible at greater distances than the equivalent word message. Due to the significant legibility benefits of symbol signs, their use is encouraged wherever practical.

In order to be effective, though, the meaning of the symbol must be understood by a high percentage of the driver population. It is therefore recommended that, when a new symbol is designed, it is tested with representative drivers and not simply shown to other traffic practitioners. Methods to do this are described in Section 14.1. Testing, which is followed by any redesign necessary to eliminate driver confusion, should alleviate difficulties in comprehension. Where symbols are understood by fewer than 85% of drivers, educational tabs may be used to assist comprehension. Good initial design will avoid signs which are ineffective and/or which require expensive educational campaigns to inform drivers of their meaning.

For details on calculating symbol size, see Section 7 (Calculating Letter Height and Symbol Size).

6.1 Arrow Type and Size

Arrows are extensively used as symbols on traffic signs for the following basic purposes:

- To indicate dimensions on or around the road, with the arrowhead indicating the direction of the associated dimension;
- To indicate the distance ahead on the road to which a sign condition refers, with the arrowhead indicating the direction of the road ahead;
- To indicate the direction and path of travel, with the arrowhead indicating direction and the shaft indicating the path of travel.

Various types of arrows and their meanings are illustrated and summarized in Table 2. The only type of arrow shaft that is tapered is the first arrow indicated in the table, a horizontal arrow with a short shaft used to indicate the dimension or extent of a parking restriction.

When an arrow with a full shaft is used, care must be taken to avoid having too short a shaft, relative to the dimensions of the arrowhead. A shaft at least double the length of the arrowhead is preferred.

Patterns for all arrows are available in Book 2 (Sign Patterns and Fabrication).

6.2 Interdictory and Permissive Symbols

The convention of using interdictory and permissive symbols superimposed on other symbols is applied throughout the OTM. The interdictory symbol consists of a red annular band or circle with a diagonal red stroke. This symbol signifies that the action represented by the symbol inside the circle and covered by the diagonal red stroke is prohibited. The diagonal red stroke runs from the top left of the circle to the bottom right, or from the top right to the bottom left, at an angle of 45 degrees to the horizontal. If the diagonal stroke at this angle obliterates the symbol representing the prohibited action, an angle as close as practicable to 45 degrees should be used.

Table 2 – Shape and Function of Arrows




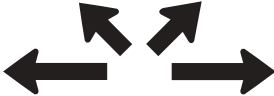




Type	Shape and Orientation	Interpretation
I (a)	 <p>Horizontal with short tapered shaft</p>	<p>Shall indicate the dimension or extent of a parking restriction.</p>
I (b)	 <p>Vertical downward with short untapered shaft</p>	<p>Shall indicate the dimension under an above-road structure or shall indicate the application of an above-road sign to a traffic lane.</p>
I (c)	 <p>Vertical upward with short untapered shaft</p>	<p>Shall indicate that the sign message applies ahead.</p>
II (a)	 <p>Horizontal or angled with full untapered shaft</p>	<p>Shall indicate direction and path of travel at the location of the sign.</p>
II (b)	 <p>Vertical upward with full untapered shaft</p>	<p>Shall indicate direction and path of travel at and beyond the location of the sign.</p>
II (c)	 <p>Angled with full untapered shaft</p>	<p>Shall indicate that the sign message applies to the lane the arrow points toward.</p>

Table 2 – Shape and Function of Arrows (cont'd)

Type	Shape and Orientation	Interpretation
III (a)	 <p data-bbox="661 743 992 796">Vertical upward with full untapered curvilinear shaft</p>	<p data-bbox="1053 614 1381 689">Shall indicate direction and path of travel for some distance beyond the location of the sign.</p>
III (b)	 <p data-bbox="661 984 921 1036">Vertical downward with full untapered curvilinear shaft</p>	<p data-bbox="1053 852 1394 927">Shall indicate a path resulting in the opposite direction of travel at the location of the sign (the U-turn).</p>

The permissive symbol consists of a green annular band or circle surrounding another symbol. This symbol signifies that the action represented by the symbol inside the circle is permitted. By inference, an action contrary to that represented by the symbol inside the circle may be prohibited.

For some applications, such as turn control signs, it is recommended that the interdictory symbol be used rather than the permissive symbol. The interdictory symbol is preferred for both comprehension and enforceability, since it more directly indicates the action prohibited. With the permissive symbol, the driver must go through an additional step to interpret that actions contrary to the permitted one(s) are prohibited. For example, it does not necessary follow to all drivers that a permissive turn control sign indicating that right turns and straight through movements are permitted

means that left turns are not allowed. Also, permissive regulatory signs for moving traffic may be more difficult to enforce than interdictory regulatory signs.

Permissive signs, however, do have a practical role in the OTM. In some cases it is very awkward to express a message using an interdictory sign where a permissive sign is very straightforward, for example signs indicating permitted parking durations. The permissive sign also is used to indicate that an upstream prohibition indicated by an interdictory sign, such as a no-passing restriction, is no longer in effect. There are still other applications, such as signing for heavy truck routes, in which the permissive and prohibitive systems can work together. In this case, the permissive signs are typically used to indicate a continuous route preferred for heavy truck use, as supplemented by prohibitive signs installed where there is a demonstrated problem with trucks using a non-designated route.

6.3 Logo Design

With the new tourist signing system, numerous logos are being used on traffic signs. In some cases these logos were developed for letterheads and are intended to be viewed at arm's length. Such logos are not easily recognized on highway signs where they are seen at 100 m or more for a second or two. For easy recognition logos should be:

- Simple in design – small details will not be resolvable at distances at which highway signs are read;
- Simple in colour – use of colour should be restricted so that the different coloured areas can be resolved at a distance – three or fewer colours are preferable;
- Evaluated at the distance at which drivers will have to read them – a design which is attractive when viewed at arm's length, may be cluttered and difficult to resolve at long distances when seen briefly.

7. Calculating Letter Height and Symbol Size

A number of factors must be considered to ensure signs are legible at an appropriate distance. The following steps should be used to determine the minimum letter height on a text sign, or the symbol size on a symbol sign, to accommodate the majority of the driving population:

- (1) **Reading Time** – Calculate the time required to read a sign with a given message.
- (2) **Perception-reaction Time** – Determine the time required to make a decision and initiate a manoeuvre, (if one is required).
- (3) **Manoeuvre Time** – Determine the time to complete any required manoeuvre before reaching the sign.
- (4) **Required Legibility Distance** – Determine the distance at which the sign must be legible, based on the travel speed (usually the speed limit) and the sum of the times obtained in Steps 1, 2 and 3 above.
- (5) **Minimum Letter Height** – Calculate minimum letter height using set ratios for legibility-distance-to-letter-height, specific to the font type used.
- (6) **Symbol Legibility** – Calculate symbol size based on legibility distance and the width of the critical detail in the symbol.

This process, while based on reasonable driver requirements, tends to be conservative, since it does not fully account for redundant information. For example, the presence of advance guide signs will likely reduce the time required to recognize and read a sign at a freeway exit.

As is noted in Section 14, this process was not used to arrive at current sign designs. Because most regulatory signs and warning signs contain few words or symbols, and are for the most part very familiar to drivers, and because relatively few signs require that a manoeuvre be completed before the sign is reached, it is likely that future analysis will show that most current signs meet driver needs. The signs which are of real concern in terms of letter height are those with long messages, with information that is new to the driver, or which must be read in their entirety. These signs include guide signs, information signs and tourism signs.

Tourism signs have been developed using a process which considered driver requirements, and the standards developed and described in Book 9 (Tourism and Commercial Signs) are based on this process. However, guide signs and information signs are continually being developed to suit the requirements of specific locations. The method outlined in this section should be used to determine appropriate letter heights for these signs. (The reading times given do not apply for changeable message signs. These are discussed in Book 10 (Changeable Message Signs).)

7.1 Reading Time

Reading time should be considered to be on the order of 1/2 second per word or number (with 1 second as a minimum for total reading time), and 1 second per symbol. If some of the sign information is redundant, then **reading time should be calculated for the critical words only.**

For example, when drivers read destination signs, they do not need to read every word of each destination. If they are looking for Kennedy Road, they do not need to read both “Kennedy” and “Road”, since the road is assumed. Similarly, if they are looking for Kennedy Road, they only need read the “Yonge” of “Yonge Street” to realize that this is not the destination they are looking for and they can go quickly to the next line in the sign. Furthermore, if drivers are reading a list of destination names, they only need to read the arrow direction for the place name they are searching for.

$$\text{Reading Time} = 1 * (\text{number of symbols}) + 0.5 * (\text{no. of words and numbers}) \text{ [secs]}$$

Notes:

- (1) Minimum reading time is 1 second.
- (2) If there are more than 4 words on a sign, a driver must glance at it more than once, and look back to the road and at the sign again. For every additional 4 words and numbers, or every 2 symbols, an additional 3/4 second should be added to the reading time.
- (3) When the sign is very close, it is seen on an angle, and becomes difficult to read. It is assumed that the sign is not visible for the last 1/2 second. Therefore, 1/2 second is added to the required reading time. The only exception to this is signs requiring a manoeuvre before the sign is reached, as they would not be read at this close distance.

7.2 Perception-reaction Time

Once a driver has detected and then read the sign, he or she is in an alerted state, ready to make a decision and initiate a manoeuvre. The time required to do this is the perception-reaction time. Many signs are for information only and do not require any decision. Perception-reaction time can be considered to be zero in these cases.

Most signs that do require a decision, require a straightforward one, e.g., stop, reduce speed. For these signs, given that drivers are in an alerted state and the choice about what to do is very limited, perception-reaction time can be considered to be 1 second. If the driver is presented with several choices about what to do, or if the decision is complex because of the roadway layout, then longer perception-reaction times will occur. In such situations, up to 2.5 seconds may be required.

7.3 Manoeuvre Time

The requirement to complete a manoeuvre, and the type of manoeuvre required can add significantly to the total time required for a driver to read and respond to a traffic sign, and consequently to the distance at which a sign must be legible. For a STOP sign, sufficient time is required for the driver to come to a complete stop by the time the sign is reached. Therefore it must be recognized at a

greater distance than a REDUCED SPEED AHEAD sign, which alerts the driver to a change of speed limit ahead, but does not require a driver to complete any actions before reaching the sign.

There are two main types of manoeuvres: lane changes and speed reductions, including those resulting in a total stop.

For lane changes, manoeuvre time is a sum of the time required to search for a gap in traffic and the time to actually perform the lane change. Gap search time increases as traffic volume increases, since it is more difficult to find suitable gaps in traffic. Lane change manoeuvre time is calculated using Table 3.

For speed reductions, a constant deceleration rate of 8.8 km/(h*sec) is assumed. Therefore, the manoeuvre time can be calculated as follows:

$$\text{Manoeuvre Time (for speed reduction) [secs]} = \frac{(\text{initial speed} - \text{final speed}) \text{ [km/h]}}{\div 8.8 \text{ [km/(h*sec)]}}$$

If the speed reduction results in a stop, as required for a STOP sign, the final speed is zero, and the above equation is simplified to the following:

$$\text{Manoeuvre Time (for stopping) [secs]} = \frac{\text{initial speed [km/h]}}{\div 8.8 \text{ [km/(h*sec)]}}$$

Table 3 – Lane Change Manoeuvre Time			
Traffic Volume	Gap Search Time [secs]	Lane Change Time [secs]	Total Manoeuvre Time [secs]
Low	3.5	4.5	8.0
High	5.3	4.5	9.8

7.4 Required Legibility Distance

The required legibility distance is calculated as follows:

If a manoeuvre *is not* required,

$$\begin{aligned} \text{Total Time Required} &= \text{Reading Time} + \text{Out-of-View Time} \\ &= \text{Reading Time} + 0.5 \text{ secs} \end{aligned}$$

If a manoeuvre *is* required,

$$\text{Total Time Required} = \text{Reading Time} + \text{Perception-reaction Time} + \text{Manoeuvre Time [secs]}$$

$$\begin{aligned} \text{Legibility Distance [in metres]} &= \text{Total Time Required [secs]} * \text{Travel Speed [km/h]} \\ &* 0.28 [(m/sec)/km/h] \end{aligned}$$

7.5 Minimum Letter Height

Table 4 shows the legibility-distance-to-letter-height ratio according to font type. Note that the ratio is higher for Series E(M) font than for the narrower Series C and D fonts that have poorer legibility. The higher ratio for Series E(M) font means that, for a given letter height, this font is legible from a greater distance than are Series C and D fonts. Clearview font has the same legibility-distance-to-letter-height ratio as Series E(M) font.

Minimum letter height is calculated as follows:

$$\text{Minimum Letter Height [cm]} = \text{Required Legibility Distance [m]} \div \text{Legibility-Distance-to-Letter-Height Ratio [m/cm]}$$

7.6 Symbol Legibility

The legibility of a symbol depends on the smallest critical detail in the symbol that needs to be resolved in order that the symbol be understood. This is often difficult to determine without testing. Consequently the guidelines that can be given are estimates only. The width of the critical detail (rather than the length) determines legibility, e.g., the width of an arrow shaft. Legibility distance is approximately 24 m/cm of symbol **width**.

Font Type	Legibility-Distance-to-Letter-Height Ratio [m/cm]
Series C	4.2
Series D	4.2
Series E(M)	4.8
Clearview	4.8

7.7 Example

Consider a destination sign with two names and two arrows, placed 30 m from the intersection on a two-lane highway, where there is no advance signing (see Figure 2). This is a situation that can occur on secondary highways, but not on primary highways where advance signing is used. The driver potentially must slow from 80 km/h to 40 km/h in order to turn at the intersection. Therefore the driver must be able to read at least two words and one arrow direction to make a decision. He or she must then begin to brake, and slow down to 40 km/h before reaching the intersection.

$$\begin{aligned} \text{Reading Time} &= (2 \text{ words}) * (0.5 \text{ secs/word}) + \\ &\quad (1 \text{ symbol}) * (1 \text{ sec /symbol}) \\ &= 2 \text{ secs} \end{aligned}$$

$$\text{Perception-reaction Time} = 1 \text{ sec}$$

$$\begin{aligned} \text{Manoeuvre Time} \\ \text{(for speed reduction)} &= \frac{(80 - 40) \text{ km/h}}{8.8 \text{ km/h/sec}} \\ &= 4.5 \text{ secs} \end{aligned}$$

$$\begin{aligned} \text{Total Time} \\ \text{Required} &= \text{Reading Time} + \text{Perception-} \\ &\quad \text{reaction Time} + \text{Manoeuvre} \\ &\quad \text{Time} \\ &= 2 + 1 + 4.5 \\ &= 7.5 \text{ secs} \end{aligned}$$

Travel Speed

$$\begin{aligned} &= \text{Mean Speed} \\ &= \frac{(T_r + T_{pr}) V_i + (T_m * V_{avg})}{T_t} \end{aligned}$$

Where: T_r = Reading Time
 T_{pr} = Perception-reaction Time
 V_i = Initial Speed
 T_m = Manoeuvre Time
 V_{avg} = Average Speed
 T_t = Total Time Required

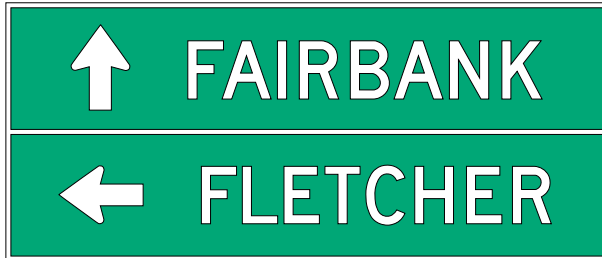
$$= \frac{(2 + 1)*80 + [4.5 * 0.5 * (80+40)]}{7.5}$$

$$= 68 \text{ km/h}$$

Required Legibility Distance

$$\begin{aligned} &= \text{Total Time Required [secs]} * \text{Travel} \\ &\quad \text{Speed [km/h]} * 0.28 [(m/sec)/(km/h)] \\ &= 7.5 \text{ secs} * 68 \text{ km/h} * 0.28 [(m/sec)/(km/h)] \\ &= 143 \text{ m} \end{aligned}$$

Figure 2 – Example Sign



Since the sign is 30 m from the turning point, the speed reduction can continue for 30 m after the sign is passed. Therefore, required legibility distance can be reduced by 30 m to 113 m.

Minimum Letter Height

- = Required Legibility Distance [m],
Legibility-Distance-to-Letter-Height
Ratio [m/cm]
- = 113 m ÷ 4.8 m/cm (for Series E letters)
- = 24 cm

The calculations for letter height are based on values intended to ensure that the majority of drivers will have ample time to read signs and carry out manoeuvres. Sign blanks come in standard sizes and the maximum letter heights possible given the sign blank size may not allow the calculated letter height. To allow some flexibility for practical reasons, it is recommended that the actual letter height used be no smaller than 90% of the calculated value.

8. Sign Layout

Following on the development of some general guidelines for the design of sign text and symbols, this section considers how these elements are arranged on the sign face. Aspects of design to consider include the length of the message on a sign, the distribution of the legend on the sign, line spacing and border space.

8.1 Message Length

For the purposes of reduced reading time and increased legibility, it is important to minimize the message length, **provided that the message does not become ambiguous**. A sign with a longer message will have to be legible from further back, and will therefore need to have larger text and a larger overall size, than a sign with a shorter message in the same environment and requiring the same driver response.

Message length will determine letter height, and therefore sign size. The method described in Section 7, which considers driver visual capabilities, reading time, perception-reaction time and manoeuvre time, should be used to calculate letter height.

8.2 Line Spacing

The spacing between lines of text on a sign should be sufficient so that the individual lines are distinguishable from a distance and the message can be clearly read. The general guideline is to provide a space of between 0.5 to 1 times the maximum letter height between each line. The sign patterns shown in Book 2 (Sign Patterns and Fabrication) adhere to this guideline.

For signs using mixed case text, the impacts on legibility and overall aesthetic effect caused by interacting ascenders (such as the vertical stroke of the letter “b”) and descenders (such as the vertical stroke of the letter “p”) need to be taken into account. If ascender/descender interference results with standard line spacing, the space between lines should be slightly increased and the legend centred vertically on the sign blank.

8.3 Border Space

Sign borders delineate the sign against its background environment, help direct driver attention to the message and can differentiate messages within groups of signs. Three kinds of borders are used on signs in the OTM:

- (1) **Inner Border:** a continuous narrow strip the same colour as the legend, just inside the edge of the sign. This type of border improves the appearance of the sign. The width of the inner border should be approximately 1.5% to 3% of the smallest outer dimension of the sign. For a 60 cm x 60 cm sign, this translates to about 1 cm to 1.5 cm.
- (2) **Outer Border:** a continuous narrow frame the same colour as the sign background, at the very edge of the sign. The outer border emphasizes the inner border by providing contrasting colour on both sides of the inner border. The width of the inner border should be approximately 1.5% of the smallest outer dimension of the sign. For a 60 cm x 60 cm sign, this translates to about 1 cm.
- (3) **Background Space Around Legend:** empty background space between the legend and the inner border. This space is required so that the legend is clearly distinguishable from a border of the same colour.

On regulatory, warning and temporary conditions signs, the minimum clearance between the legend and inner border should be approximately 4% to 10% of the smallest outer dimension of the sign. For a 60 cm x 60 cm sign, this translates to about 2.5 cm to 6 cm.

On directional guide signs and other information signs, the minimum side clearance between the legend and the sides of the inner border should be equal to the height of the largest letter. The minimum clearance to the top and bottom of the inner border should be 66% to 100% of the largest letter height, minus the width of the inner border.

9. Reflectorization and Illumination

Signs that convey messages of warning, important regulations or essential directional information that are relevant during the hours of darkness need to be legible and conspicuous at night, as well as during the day. Since conspicuity depends to some degree on colour code recognition, the colour of the sign must appear the same by night as by day. The engineering tools used for maintaining a reasonable level of sign legibility and conspicuity at night are reflectorization and illumination.

9.1 Retroreflective Sheeting

Most signs are assembled by applying thin adhesive sheeting materials in the background and legend colours to a rigid sign blank. Some types of sheeting contain tiny glass beads or prisms that refract the light so most of it is reflected straight back to the source, which is a vehicle with headlights. Therefore, the light from the headlights is very efficiently used, with a significant amount of it reflected back towards the driver's eyes. Material having this property is known as retroreflective sheeting.

There are different types of retroreflective sheeting. Types in use today on road signs include the following:

- Type I – Engineering Grade (enclosed lens glass-bead material);
- Type II – Super-Engineering Grade (enclosed lens glass-bead material);
- Type III – High Intensity Grade (encapsulated glass-bead material);
- Type IV – High Intensity Prismatic (non-metalized micro-prismatic material);
- Type VIIA – Diamond Grade (non-metalized micro-prismatic material, for short range viewing);
- Type VII B – Diamond Grade (non-metalized micro-prismatic material, for long range viewing).

In general, the higher the type number, the greater the amount of light reflected back to the driver's eyes. Each type of retroreflective sheeting is characterized by a range of R-values. R is known as the coefficient of retroreflectivity and indicates the proportion of light reflected back to the driver. The units for R are candelas per lux per square metre ($\text{cd}/(\text{lux}\cdot\text{m}^2)$).

R-values associated with each type of retroreflective sheeting are detailed in the ASTM Specification D 4956-95 (or its subsequent revisions). In Canada, the CGSB Specification 62-GP-11M (or its subsequent revisions) also specifies retroreflective sheeting. The main difference between the ASTM standard and the CGSB standard is that the CGSB standard sets out a performance level requirement at 50 degrees entrance angle, while the widest entrance angle for which the ASTM standard specifies a performance level is 30 degrees. If signs are to be installed where viewing angles are greater than 30 degrees (e.g., if the sign has a very large horizontal mounting offset), the CGSB specification should be used.

In the specifications, R-values are provided for different entrance angles and observation angles. The entrance angle is the angle between the headlight beam and the perpendicular to the sign face (see Figure 3). The observation angle is the angle formed by light travelling from the headlight and reflected off the sign back to the driver's eye (see Figure 4). Larger entrance and observation angles result in lower R-values (see Sections 12.2, 12.3 and 12.4).

The entrance angle is affected by:

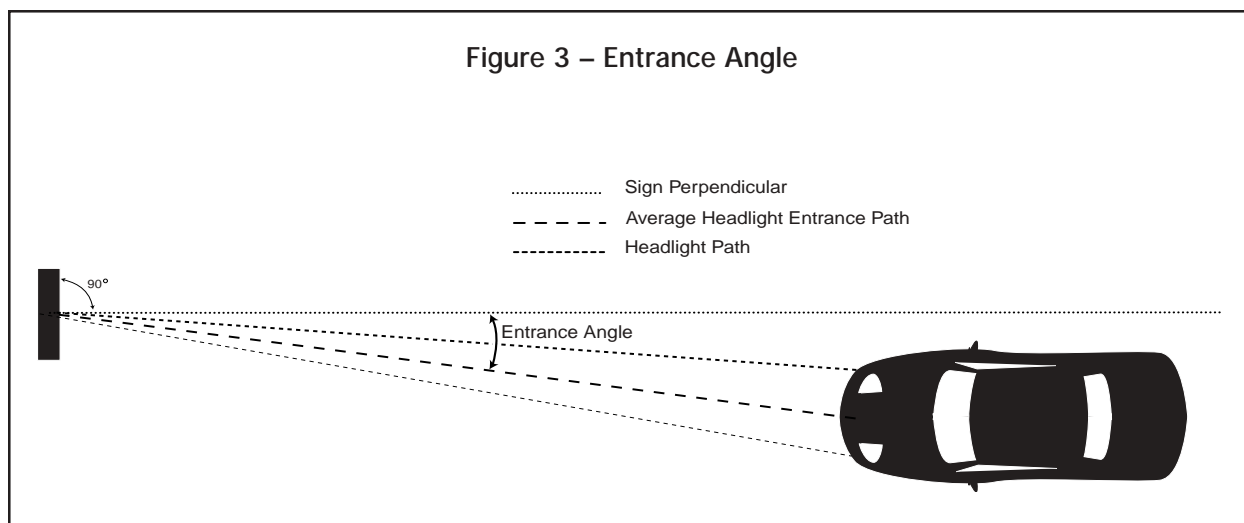
- The horizontal sign offset;
- Sign mounting height (vertical offset);
- The distance between the vehicle and the sign;
- The travel lane of the vehicle;
- The curvature of the roadway;
- Tilt angle of the sign about its vertical axis (horizontal angling of side-mounted signs); and
- Tilt angle of the sign about its horizontal axis (vertical angling of overhead signs).

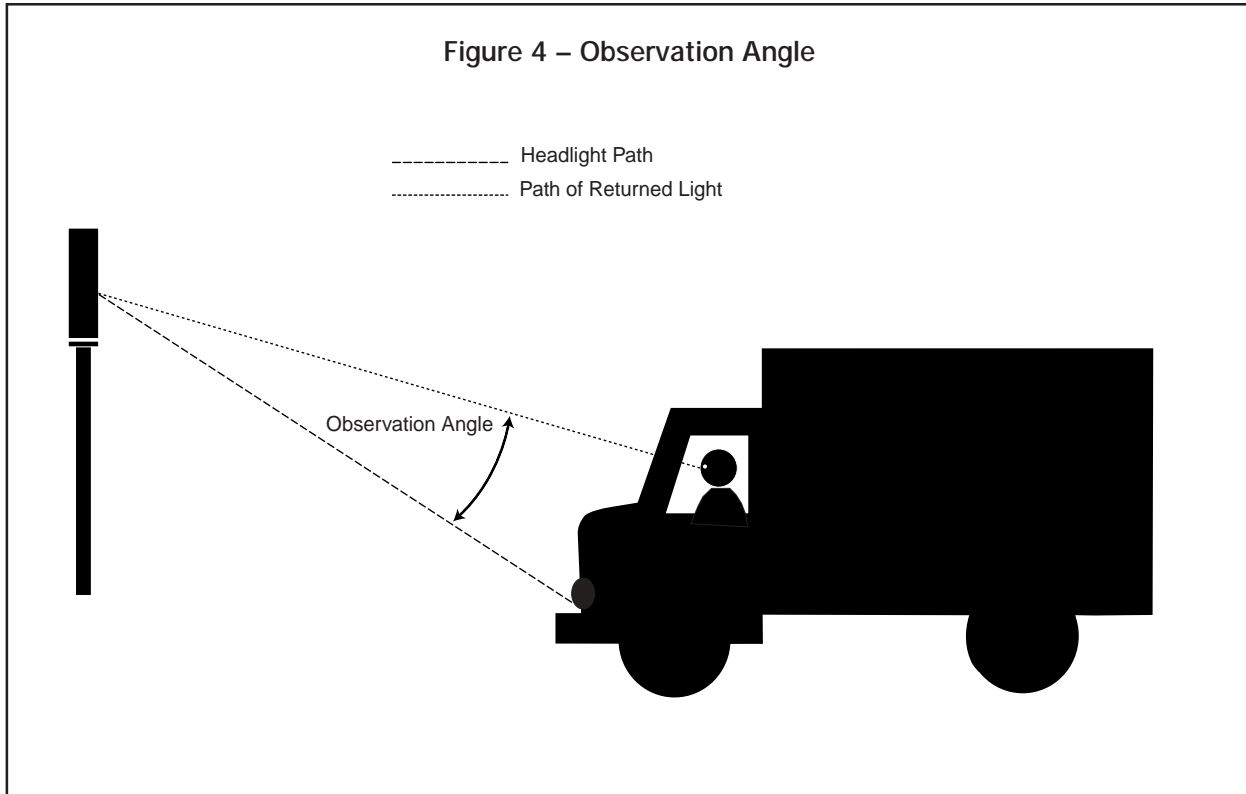
The observation angle is affected by:

- The distance between the vehicle and the sign;
- Sign mounting height (vertical offset); and
- The distance between headlight height and driver eye height.

The R-values vary according to colour, with darker colours having generally lower R-values. For example, minimum ASTM R-values for new Type I and Type IV sheeting of various colours, measured at an observation angle of 0.2 degrees and an entrance angle of 4 degrees, are shown in Table 5. These R-values should be considered as guidelines only. Typically, new sheeting has much higher values, by on the order of 30%, than the minimum ASTM values indicated in the table.

The OTM mandates the use of high intensity sheeting for several signs which are critical from a safety standpoint, that is, failure to see or heed these signs at night could have serious consequences (see Book 5 (Regulatory Signs), Book 6 (Warning Signs) and Book 7 (Temporary Conditions)). However, it may make sense to use high intensity sheeting for other applications also,





for new signs installed and as part of a regular sign replacement program. In addition to the obvious benefit of improving legibility, high intensity sheeting is also more cost effective over the life of the sign.

While the capital cost of high intensity sheeting is higher, the life cycle is also longer. In addition, the percentage of the new R-value that is guaranteed to the end of the life cycle is generally higher with

Table 5 – ASTM R-Values

Colour	Type I	Type IV
White	70	250
Yellow	50	170
Orange	25	100
Green	9	35
Red	14	35
Blue	4	20
Brown	1	7

* Observation Angle = 0.2 Degrees
Entrance Angle = -4 Degrees

higher intensity sheeting. For example, with Type I sheeting, 50% of its new R-value is guaranteed at the end of 7 years (R at end of life cycle = 35 for white sheeting at observation angle = 0.2 degrees and entrance angle = 4 degrees), while with Type III sheeting, 80% of its new R-value is guaranteed at the end of 10 years, and has been observed to be maintained after even 20 years (R at end of life cycle = 200 for identical conditions).

9.2 Illumination

As an alternative or supplement to high intensity sheeting, external or internal illumination of the sign may be used. As with retroreflective sheeting, all sign illumination must result in sign colours appearing the same by night as by day. Illumination may be by one of the following means:

- A light behind a translucent sign face, illuminating the legend and/or background;
- An attached or independently mounted light source designed to direct essentially uniform illumination over the entire sign face;
- Luminous tubing shaped to the legend or symbol.

Ordinary street or highway lighting does not meet the requirements for sign illumination. However, street lighting can aid visibility. The presence of street lighting should be taken into consideration in selecting the exact placement of signs which are not required to be reflectorized or illuminated.

10. Contrast

Contrast refers to differences in colour or in brightness which allow a target, such as a sign message or symbol, to be seen against the sign background. Contrast is dependent on a property called reflectance, which represents the amount of light reflected back from a sign, relative to the amount of light shining on the sign. Contrast is defined in various ways. Contrast can be calculated according to the following formula:

$$\text{Contrast} = \frac{R_L - R_B}{R_B}$$

$$\text{Contrast Ratio} = \frac{R_L}{R_B}$$




Where: R_L is Reflectance of Legend; and
 R_B is Reflectance of Background.

Contrast affects legibility. Where there is a low level of contrast (e.g., orange letters on a light blue background) legibility will be poorer than with higher contrast (e.g., black letters on a white background). Table 6 shows acceptable and recommended combinations for sign colours used in the Ontario Traffic Manual, based on contrast.

During the day contrast is determined by the degree to which various colours reflect light. At night, light is provided by streetlights and headlights. Even with these light sources there is insufficient light reflected from a non-retroreflective sign to allow it to be read. In order to raise the level of light reflected back to the observer, retroreflective sheeting is used (see Section 9 (Reflectorization and Illumination)). For a sign with retroreflective sheeting, reflectance at night is measured by the R-values of the materials used for the sign legend and background.

Table 6 – Acceptable Sign Colour Combinations Based on Brightness Contrast

Background Colour	Legend Colour											
	Red	Black	White	Orange	Yellow	Brown	Green	Blue	Purple	Light Blue	Coral	Brilliant Yellow-Green
Red	Not recommended	Not recommended	Acceptable for day or night	Acceptable for day or night	Acceptable for day or night	Not recommended	Not recommended	Not recommended	Not recommended	Not recommended	Not recommended	Not recommended
Black	Not recommended	Not recommended	Acceptable for day or night	Acceptable for day or night	Acceptable for day or night	Not recommended	Not recommended	Not recommended	Not recommended	Not recommended	Not recommended	Not recommended
White	Acceptable for day or night	Acceptable for day or night	Not recommended	Acceptable for day or night	Not recommended	Acceptable for day or night	Acceptable for day or night	Acceptable for day or night	Acceptable for day or night	D	Not recommended	D
Orange	Acceptable for day or night	Acceptable for day or night	Acceptable for day or night	Not recommended	Acceptable for day or night	Acceptable for day or night	Acceptable for day or night	Acceptable for day or night	Acceptable for day or night	Acceptable for day or night	Acceptable for day or night	Acceptable for day or night
Yellow	Acceptable for day or night	Acceptable for day or night	Acceptable for day or night	Acceptable for day or night	Not recommended	Acceptable for day or night	Acceptable for day or night	Acceptable for day or night	Acceptable for day or night	Acceptable for day or night	Acceptable for day or night	Acceptable for day or night
Brown	Acceptable for day or night	Acceptable for day or night	Acceptable for day or night	Acceptable for day or night	Acceptable for day or night	Not recommended	Not recommended	Not recommended	Not recommended	Not recommended	Not recommended	Not recommended
Green	Not recommended	Not recommended	Acceptable for day or night	Acceptable for day or night	Acceptable for day or night	Not recommended	Not recommended	Not recommended	Not recommended	Not recommended	Not recommended	Not recommended
Blue	Not recommended	Not recommended	Acceptable for day or night	Acceptable for day or night	Acceptable for day or night	Not recommended	Not recommended	Not recommended	Not recommended	Not recommended	Not recommended	Not recommended
Purple	Not recommended	Not recommended	Acceptable for day or night	Acceptable for day or night	Acceptable for day or night	Acceptable for day or night	D	D	Not recommended	Not recommended	Not recommended	Not recommended
Light Blue	Acceptable for day or night	Acceptable for day or night	Acceptable for day or night	D	Not recommended	Acceptable for day or night	Acceptable for day or night	Acceptable for day or night	Acceptable for day or night	Not recommended	Not recommended	Not recommended
Coral	Acceptable for day or night	Acceptable for day or night	Acceptable for day or night	Acceptable for day or night	Not recommended	Acceptable for day or night	Acceptable for day or night	Acceptable for day or night	Acceptable for day or night	Not recommended	Not recommended	Not recommended
Brilliant Yellow-Green	Acceptable for day or night	Acceptable for day or night	Acceptable for day or night	D	Not recommended	Acceptable for day or night	Acceptable for day or night	Acceptable for day or night	Acceptable for day or night	Not recommended	Not recommended	Not recommended

- Legend:
-  Acceptable for day or night
 -  Not recommended
 -  Acceptable only for day application or night with external illumination

For positive contrast signs (e.g., white legends on green or blue or red backgrounds), brightness contrast at night has a major impact on legibility. Laboratory studies have shown that:

- Legibility falls off rapidly for contrast values below about 4:1;
- Best legibility is found for contrasts in the region of 10:1 to 15:1;
- Beyond 15:1, legibility very gradually decreases, but even at 100:1 it is still greater than at 4:1.

For this reason, sheeting combinations whose relative R-values produce contrast ratios below a value of 4:1 are not recommended. At the upper end, laboratory studies have shown that night legibility is significantly reduced for Type VII legends on a Type I (Engineering Grade) background. Thus this combination is not recommended.

Some signs, such as STOP signs, are fabricated by silk screening coloured reflective paint onto white sheeting. When new, reflective paint tends to have a lower R-value for a given colour than its equivalent level of sheeting, resulting in higher contrast ratios with the white sheeting. However, the reflective paint fades more quickly than sheeting, and with time, contrast ratios fall below those for the same types of signs surfaced entirely with sheeting. For best results, it is recommended that components of silk screened signs (e.g., sheeting, ink, clear coating) be provided from the same manufacturer to ensure compatibility of the components.

For negative contrast signs, that is black legends on white or orange backgrounds, the retroreflectance of the black sheeting is zero, and a contrast ratio cannot be calculated. For such signs, nighttime legibility depends on sign luminance. Studies show that with type C letters, there is little impact of sheeting on legibility – legibility is as good with Type I as with Type IV. With type D letters, Type III and IV sheeting increase legibility over that of Type I and II by about one-third.

11. Selecting the Sign Size

Books 5, 6, 7, 8 and 9 of the OTM show sign designs and minimum sizes of signs, typically as related to type and speed of roads. Most signs currently in use are considered to meet the needs of the majority of drivers, based on experience in Ontario and elsewhere. However, these signs have not all been systematically analyzed in accordance with the sign design principles described herein. This is proposed to be done, through the process outlined in Section 14. Over a period of time, revisions and refinements to the OTM will be made on a continuing basis. At any given time, the OTM Books and the minimum sign sizes shown therein represent best guidance and practice based on current knowledge at the time.

In some situations, it may be desirable to increase the sign size over those shown in the OTM. Much of the information discussed in the above sections (especially Section 7), including font type, letter size, symbol size and sign layout with appropriate spacing and borders, can be used to determine whether increased sign size should be used. The standard sign size can then be adjusted to fit the next larger standard sign blank size available (See Book 2 (Sign Patterns and Fabrication)).

Some of these situations where larger sign size may be desirable, include the following:

- If there are factors that impact the amount of time a driver can devote to reading the sign, such as a complex and distracting background environment, heavy traffic volumes and a high density of intersections and driveways requiring complex choices, consideration should be given to moving up to the next largest blank size, to increase the distance at which the sign is legible.
- If the required sign size is prohibitively large and if attempts to redesign the sign have not succeeded in the short term, consideration should be given to using a higher intensity sheeting to improve nighttime legibility. For example, increasing the intensity of sheeting from Type II to Type VII for both legend and background has the equivalent impact of increasing night legibility distance by 15 m to 30 m, or increasing the letter height by 2.5 cm to 5 cm for nighttime conditions only.
- It may not be economically feasible to install all new signs and to replace all damaged and aged signs with the sizes required to accommodate 85% of the driving population. In this case, priority should be given to signs that are higher on the sign hierarchy (see Section 4).
- If there is a known challenged driver population in a given area, such as in the vicinity of a Senior Citizens' centre, consideration should be given to moving up to the next largest blank size.

12. Sign Position

Drivers are very limited in how many places they can look as they drive along the roadway at speeds of 10 m to 30 m every second (about 40 km/h to 110 km/h). Therefore, standardization of sign position is important so that drivers can quickly find signs in expected locations, and spend the little time available reading them rather than looking for them. Standardization of position, however, cannot always be attained in practice, since signs must be placed in the most advantageous position and must be adapted to the road design and alignment.

12.1 Side and Overhead Mounting

The general rule for sign placement is to locate signs on the right side of the road to meet driver expectations. In some circumstances, signs may be most conspicuous when placed on a channelizing island, overhead or, as in the case of sharp right curves, on the left shoulder of the road directly in front of approaching vehicles.

In addition, there are situations where it is advisable to place a second sign on the left side of the road to supplement the primary sign normally placed on the right side. Examples are multi-lane one-way streets, expressways and locations where collision experience has shown that the drivers are failing to see the primary signs.

Overhead mounting should preferably be used for lane designation signs and as required for multi-lane facilities. Certain classes of directional guide signs on expressways are typically overhead mounted. For more information on standards for mounting overhead signs, see Book 3 (Sign Support and Installation).

12.2 Horizontal Mounting Offset

Typical examples of horizontal mounting offsets for ground-mounted signs are illustrated in Figures 5 and 6. The basic guidelines for horizontal mounting offsets are as follows:

- **Rural areas without raised curbs:** 2 m to 4 m from the outside edge of the outer traffic lane;
- **Urban or residential areas with raised curbs:** 30 cm to 2 m from the curb line.

Where restricted by physical features such as cliffs, or structural features such as bridge supports, the horizontal offset should be as close as possible to the above guidelines. For some signs the horizontal offsets do not conform to the general guidelines. These exceptions are discussed on a sign-by-sign basis throughout the Ontario Traffic Manual.

In the event that vehicles must leave the roadway, the horizontal offset should allow for a safe and practical clearance so that vehicles are less likely to strike sign supports. Advantage should be taken of existing guide rails, overhead structures and other physical features to minimize the exposure of traffic to sign supports. Otherwise breakaway or yielding supports should be used.

Where there is a range of horizontal mounting positions available, minimizing the horizontal offset is recommended, provided that a practical clearance between the roadway and sign is maintained. Minimizing the horizontal offset reduces the entrance angle, which in turn increases the coefficient of retroreflectivity, R , and improves night legibility of the sign (see Section 9.1). Drivers can also keep a sign with a smaller offset in their peripheral vision for a longer time, which increases the time available for viewing the sign.

Figure 5 – Height and Location of Signs (Typical Installation)

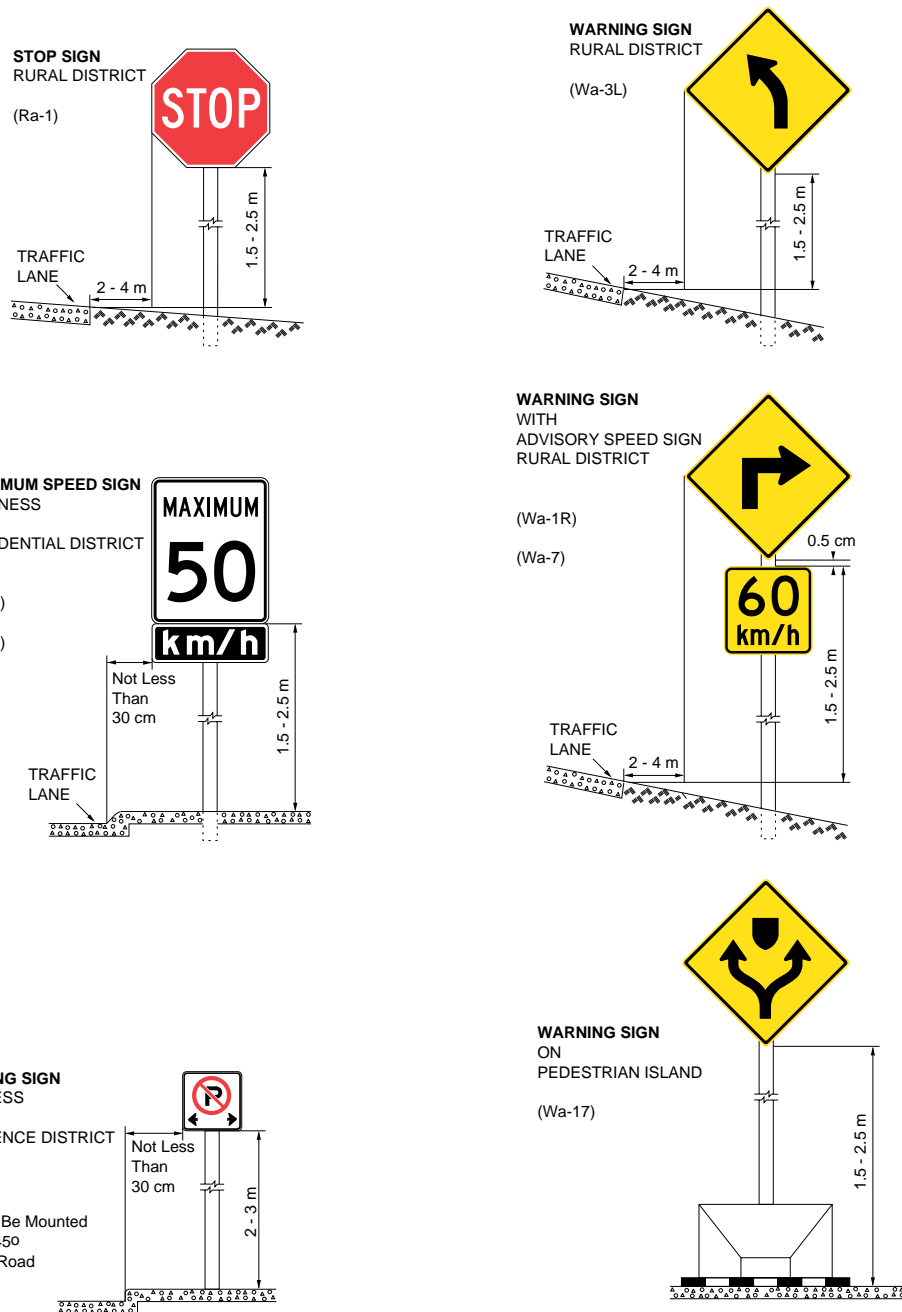
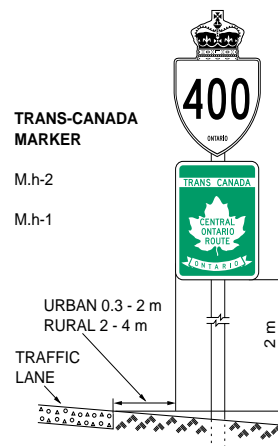
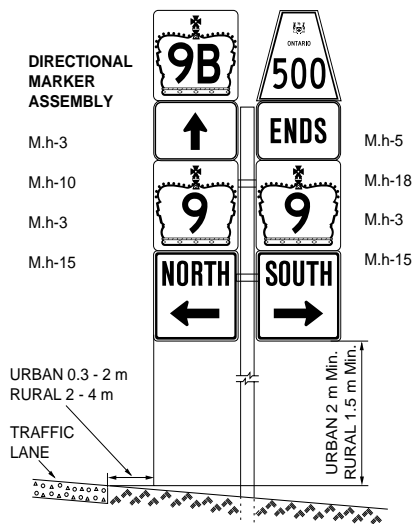
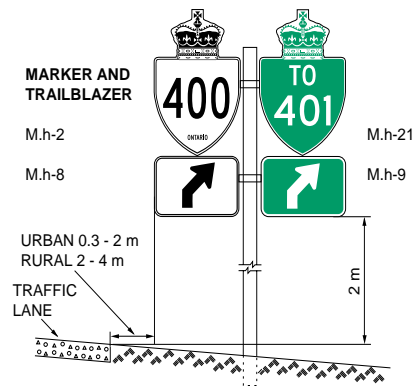
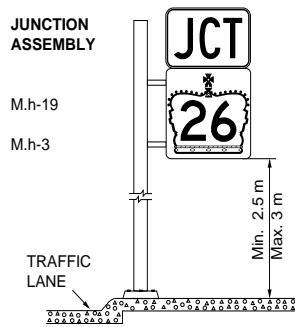
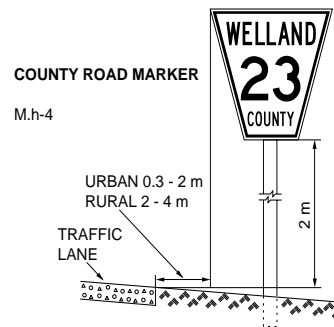
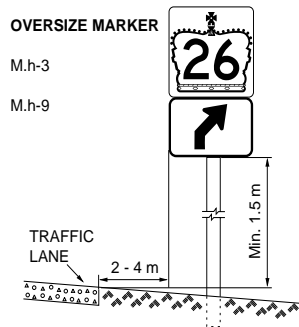


Figure 6 – Height and Location of Markers



NOTE: Where shoulder width is less than 3 m signs should be erected 60 cm from edge of shoulder

12.3 Vertical Mounting Offset

Typical examples of vertical mounting offsets for ground-mounted signs are illustrated in Figures 5 and 6. The basic guidelines for vertical mounting offsets of ground-mounted signs include the following:

- **Areas with no pedestrians and without raised curbs:** 1.5 m to 2.5 m from outer edge of outer lane to bottom of principal sign, regardless of whether there is a tab sign mounted beneath principal sign;
- **Areas with no pedestrians and with raised curbs:** 1.5 m to 2.5 m from curb line to bottom of principal sign, regardless of whether there is a tab sign mounted beneath principal sign;
- **Areas with pedestrians:** 2 m to 3 m from ground elevation at the base of the sign post to the bottom of the overall sign, including tab if present.

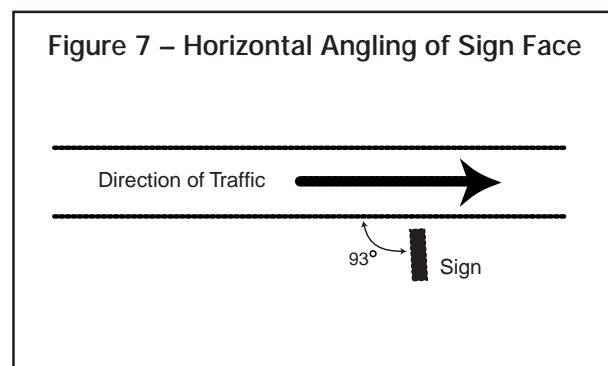
For overhead signs, the minimum vertical mounting offset ranges from 4.5 m to 5.3 m, measured from the road surface to the bottom of the overall sign, including tab if present. For overhead signs mounted on dedicated overhead sign supports, such as aluminum trusses, the vertical mounting offset must be at least 5.3 m. If an overheight truck hits one of these large signs, it may bring down the entire structure, posing a safety risk and having significant restoration cost implications. If, however, the same sign is mounted on an overpass bridge, a 4.5 m clearance is sufficient. The 4.5 m clearance is equal to the clearance of the bridge, itself, and if the sign is damaged it will likely not bring down the bridge. Similarly, if a sign is mounted on a traffic signal arm, there is no benefit in making the vertical clearance for the sign greater than the 4.5 m clearance for the traffic signal. Overhead signs should be centred over the traffic lanes to which they apply.

Where there is a range of vertical mounting positions available, minimizing the vertical offset is recommended, provided that the minimum requirement is met. Mounting the sign lower reduces the entrance angle, which in turn increases the coefficient of retroreflectivity, R , and improves night legibility of the sign (see Section 9.1).

12.4 Horizontal and Vertical Angling of Sign Face

Generally, signs must be mounted at approximately right angles to the direction of traffic, facing the traffic that they are intended to address. Exceptions to this rule include regulatory parking control signs. These signs should be placed at an angle of 30 to 45 degrees to the flow of traffic, and should always be visible to approaching traffic.

Ground-mounted signs should be angled horizontally slightly away from traffic (by about 3 degrees), so that glare is reduced (see Figure 7). Glare is a bright reflection off the sign's smooth surface, which makes the sign legend unreadable while the driver's eye is within a certain angle of the sign. As noted in Section 9.1, horizontal angling of ground-mounted signs impacts the entrance angle for night reflectivity. Increasing the entrance angle decreases R , the coefficient of retroreflectivity, which in turn reduces night legibility of the sign. By angling side-mounted signs slightly away from traffic, the entrance angle is increased, and unfortunately legibility is decreased. The benefits of reduced glare,

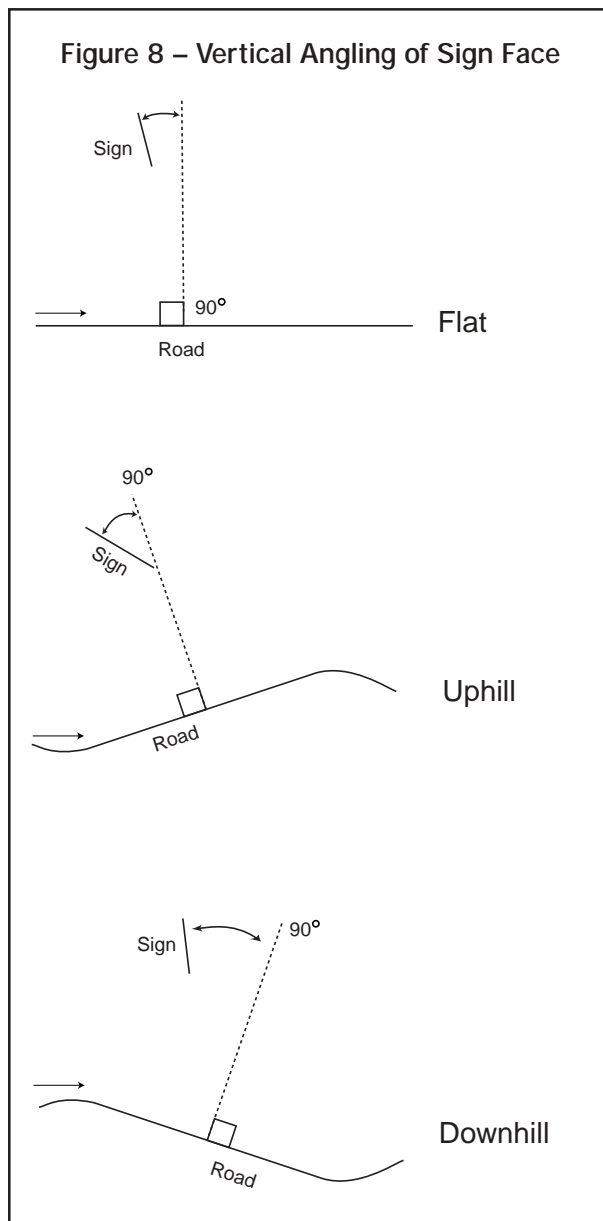


however, are seen to outweigh the disbenefits of slightly decreasing night legibility. Therefore, the angling of ground-mounted signs slightly away from the driver is recommended.

With overhead signs, the glare problem is not as severe as with ground-mounted signs, since the height differential between the overhead sign and the driver's eye is much greater. It is good practice,

then, to tilt overhead signs slightly toward traffic off the vertical, by about 3 to 5 degrees (see Figure 8). Tilting the sign in this direction reduces the entrance angle, and therefore increases sign legibility at night.

For both ground-mounted and overhead signs, the angle of the sign face should be measured relative to the direction of traffic at the location where the sign is first read. The direction of traffic is dependent on the road alignment and slope. For example:



- On horizontal curves, the angle of the sign face relative to traffic direction should be measured from the tangent of the curve at the point where the sign must first be read;
- On vertical curves, the tilt angle of an overhead sign should be greater on uphill slopes, and less on downhill slopes, than the tilt angle for flat terrain.

12.5 Other Position Criteria

Typical sign placement is upstream of the condition to which the sign applies. Signs should normally be placed individually on separate posts, except where one sign supplements the other, or where route or directional signs must be grouped. Enough space should be allowed between signs for the driver to read the entire message on each sign. For standard regulatory signs, which contain a symbol and one or two words, a minimum spacing of 50 m is required for speeds of 60 km/h and less, 75 m for speeds of 70 km/h to 80 km/h, and 100 m for speeds of 90 km/h or more. For destination, tourist or information signs containing considerable text, reading time and out-of-view time must be calculated (see Section 7). Minimum spacing is then determined as follows:

$$\text{Spacing [m]} = \frac{(\text{Reading Time} + \text{Out-of-View Time}) [\text{sec}] * \text{Speed [km/h]}}{3.6 [(m/\text{sec})/(\text{km/h})]}$$

13. Bilingual Sign Design

Signs with text in both English and French may be installed in designated areas, conforming with municipal and provincial policies (see Book 1, Section 8 for information on bilingual signing policy). Bilingual messages can be presented either on the same sign or on separate signs. If both languages are shown on one sign, one of two options must be used:

- English text on the left side and French text on the right side; or
- English text on the upper portion of the sign with French text below.

If a pair of signs is used instead, the English text must be presented first and its French text equivalent must be located beyond it. The signs should be placed far enough apart to be both legible, but close enough so that their individual messages can be recognized as being equivalent. For longer texts, the two-sign approach is preferred, to avoid overloading the driver with what may appear as a lengthy message.

Bilingual signs must conform to established sign design principles for application, location, position, colour, shape and size. They must employ the same symbols, arrows and borders, and where possible must maintain the same fonts and equivalent letter heights as their corresponding English-only versions. Sign patterns for bilingual signs are shown in Book 2 (Sign Patterns and Fabrication).

14. Process for Assessing and Revising Sign Designs

A cursory analysis would suggest that most signs currently in use probably do meet the needs of the majority of drivers, despite the fact that they were designed in the absence of explicit knowledge of driver needs. However, a systematic analysis is required because there are signs which appear to be inadequate. Given the aging of the driver population and the increasing complexity of the road network, it is important that such signs be considered for redesign. In addition, such an analysis is needed to ensure that sign sizes designated for various road types and speed zones are appropriate.

Due to the time required to complete an analysis of this depth, it is not possible to incorporate the analysis results for the sign designs of the first few OTM Books to be released. A process has been started, however, which will eventually lead to the update of sign designs as required throughout the entire Ontario Traffic Manual (see Book 1, Sections 2.5 and 5.12). The process involves the following steps:

- (1) On an interim basis, for this edition of the Ontario Traffic Manual, incorporate essentially the current versions of the regulatory, warning, temporary conditions, and guide signs appearing in the Ontario Manual of Uniform Traffic Control Devices (MUTCD), specifying different minimum sizes of signs for different speed ranges, according to rule of thumb and commonly used sign blank sizes. Increases above these minimum sizes may become desirable when other factors and sign design principles are taken into account.

(2) On a longer-term basis, adopt a procedure for sign review and revision, involving the Ontario traffic engineering community, through the Ontario Traffic Manual Committee (OTMC) and its subcommittees. This procedure is envisaged as follows:

- (a) **Existing Signs** – Identify those signs which appear most problematic, and subject them to systematic analysis of driver requirements, to determine the appropriate letter height. Develop and test for comprehension alternative sign designs for any signs that are found to be deficient, or that appear to require significant increases in sign size. Discuss alternatives at the OTMC and approve the approach preferred by the OTMC, which would be incorporated in the next edition of the relevant Book of the OTM. Over time, all existing signs should be reviewed in this manner.
- (b) **New Signs** – Any new sign designs (all categories) should be developed on the basis of current knowledge of driver needs, as discussed in Section 2. If the resulting sign designs are very large or are substantially larger in size than existing signs, raising questions as to feasibility, this may require an alternative sign design or an alternative signing approach.

14.1 Comprehension Testing

When signs are developed, they are frequently tested in a number of ways. Generally they are shown to a committee, usually of traffic engineers or related professionals, who comment on the adequacy of the design. Several alternative designs may be shown to focus groups to determine driver preference. They may then be mounted at a test location, and any public feedback about them is

recorded before a final design emerges. However, none of these methods ensures that a sign will be adequately legible for unfamiliar drivers, or that it will be comprehended by the majority of drivers. Traffic engineers have a much greater familiarity with traffic engineering terms, and messages such as “limited sight distance” which may be very meaningful to them, turn out to be poorly understood by the general public. Focus groups reveal preference, which may have to do with attractiveness of a design, but not necessarily with the ability of individual drivers to comprehend a sign, particularly when it is viewed very briefly as the driver passes by.

To ensure adequate legibility, the procedure for determining letter height described in Section 7 should be followed. To ensure that the majority of drivers understand the sign it should be tested with a representative sample of drivers – on the order of 200, with varying age, education and language backgrounds. Such studies were carried out to ensure the bilingual freeway signs, installed in 1993, would be comprehended by the majority of drivers.

If a sign must be produced quickly, there may be insufficient time for a systematic test. In this case, there are some simple steps that will assist engineers to develop a sign likely to be understood by the general public. The sign, or signs if there are alternative designs, must be shown to a sample of the general public. Office employees who are familiar with engineering language, even though they are not themselves engineers, are not ideal candidates because of their “inside knowledge”. A minimum sample would be 24 drivers, and this sample should include approximately 1/3 under age 25, 1/3 aged 26 to 55, and 1/3 over 55 years. Less educated rather than better educated drivers are preferable. When there are several alternatives of one sign to be tested, it is preferable that each driver be tested with only one version of the sign.

Sample signs should be drawn up. Each sign should be placed in a background typical of the context in which it will be seen, e.g., on a freeway, at an urban intersection. Drivers should see the sign for a few seconds only – this is generally the length of time they have to figure out a sign on the roadway. Drivers should then be asked simply what the sign means and their answer recorded. This technique is preferable to using a multiple choice approach, because it will reveal potential confusions. For example, the SLIPPERY WHEN WET sign is interpreted by many drivers as WINDING ROAD AHEAD. Where fewer than 80% (20/25) of drivers tested understand the sign, redesign is required. The drivers' wrong answers will assist in determining what aspects of the design need to be changed.

Where comprehension is poor, and redesign is required, it is often the case that only small changes need be made. For example, the comprehension of the SLIPPERY WHEN WET sign was greatly improved by merely crossing the lines trailing from the vehicle.

The purpose of signs is to convey information to drivers. Signs which are poorly comprehended are ineffective. While education campaigns can assist in helping drivers understand a new sign, such campaigns are costly, and must be repeated to reach drivers new to the road or new to the area. It is far more preferable to use a method of sign development and testing that helps ensure that the majority of drivers comprehend the sign without education being required.

15. Operational Programs

The previous sections have discussed the importance of installing well-designed signs in appropriate locations that are comprehended by a high percentage of drivers. However, ongoing operational programs instituted by Road Authorities are recommended to ensure the continuing effectiveness of the signs. This section outlines recommended operational practices to optimize the benefits of good sign design. (See Book 3 (Sign Support and Installation) and Book 4 (Sign Maintenance) for further details.)

15.1 Sign Maintenance and Replacement

Poorly maintained signs lose their authority as traffic control devices. Damaged, defaced or dirty signs, as well as signs with degraded reflective sheeting, are ineffective and discredit the agency responsible for them. All traffic signs should be kept in proper position and should be clean and legible at all times. Damaged signs and signs with sheeting that has aged beyond the guaranteed lifetime should be repaired or replaced as soon as possible. Special care should also be taken to ensure that weeds, shrubbery, construction materials and snow are not allowed to obscure the face of a sign.

To ensure adequate maintenance, a suitable schedule for inspection, cleaning and replacement of signs should be established. A daytime inspection of all signs should be carried out on a regular basis. Suggested times are as follows:

- During the fall, prior to the onset of hazardous winter conditions and decreased daylight hours;
- During the spring, to identify signs damaged during the winter months, prior to seasonal traffic increases in some areas.

It is recommended that Road Authorities institute a sign inspection program to regularly inspect sign conditions by night, to identify sign performance and condition. A three-year inspection cycle is suggested as a reasonable period to inspect all signs in the jurisdiction, that is, one third of the sign inventory inspected each year. It is suggested that reflectivity performance be classified according to three categories: acceptable, marginal and unacceptable. The categories would represent the residual effective life of the sign based on its reflectivity.

The program of night inspection could be based on visual observation of material reflectivity performance by comparing signs to material samples representing the acceptable, marginal and unacceptable conditions. It is recommended that visual night inspections be performed:

- By older persons, preferably 50 years old or older;
- Using low-beam headlights;
- From the distance that the sign needs to be legible in order that drivers can read it and respond to it in time.

There are also hand-held and vehicle-equipped reflectometers on the market. These devices may be used either to spot-check the reliability of the visual inspection, or as part of a more rigorous process. While a vehicle-equipped reflectometer is expensive, some versions enable sign inspection during the day and without having to leave the vehicle. These features would reduce the staff resources spent on inspection and would limit the inspection time to regular working hours.

15.2 Sign Inventory

A sign inventory program is recommended for cataloguing all signs by type, size, material, date of installation and sign condition. Consideration should be given to bar coding signs with this information as a means of permanently identifying and tracking new signs. Such an initiative would greatly facilitate a sign inspection program.

The sign inventory database would help Road Authorities keep track of items such as the following:

- When signs were installed and replaced;
- When the sheeting service life has expired;
- When the bulbs of illuminated signs should be replaced, based on life expectancy;
- Improved versions of signs to be installed when replacements are required. Improvements may be related to sign design features such as legibility, comprehension, symbolism and night reflectivity;
- Performance record of retroreflective sheeting, using input from night inspection program;
- Priorities for sign replacement;
- Budgetary impacts.

Enquiries regarding the purchase and distribution of this manual should be directed to:

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