SKS 2.2.5-C.1 Introduction

Where no intersections are present, the necessary separation between a highway and a frontage road can be determined by considering factors such as ditch width, sideslopes, grade height differential and headlight glare. When a cross road is encountered, interactions are created that require the consideration of additional geometric parameters and vehicle dynamics. These factors include:

- Turning vehicle wheel paths
- Stopping and entering sight distances
- Traffic control device space requirements
- Weaving, merging, and capacity
- Vehicle storage

SKS 2.2.5-C.2 Turning Vehicle Wheel Paths

The two controlling turning manoeuvres that influence highway and frontage road separation distance are U-turns and reverse turns. Figure SKS 2.2.5-C.1 illustrates the minimum separation between the highway and the frontage road to permit 180° turns between highway and frontage roads without encroachment into other traffic lanes of the highway or frontage road (while allowing encroachment on opposing crossroad traffic). Figure SKS 2.2.5-C.2 illustrates the minimum separation required for reverse turns without encroachment on any of the opposing traffic lanes on the cross road.

The minimum separation for passenger vehicles (P), medium single units (MSU), heavy single units (HSU) semi-trailers (WB-20), and turnpike double units (TPD) are outlined in Table SKS 2.2.5-C.1.

When determining the required separation distance between a highway and frontage road, it is vital to select a design vehicle based upon the appropriate traffic composition for the location of interest. Traffic composition data may be obtained from Traffic Services. When traffic composition data is not available, the HSU is an appropriate design vehicle for most situations.

Minimum separation values specified in Table SKS 2.2.5-C.1 only provide sufficient distance to allow for very tight, slow turning manoeuvres. Furthermore, minimum separation distances often require the turning vehicle to partially or fully encroach on the opposing lane of the cross road in order to complete a turning manoeuvre. Consequently, minimum separation distances are not considered to be desirable and should only be used on very low volume facilities and in situations where absolutely necessary.

To prevent the problems associated with the use of minimum separation distances, more appropriate separation distances were selected ("Desirable" separation distances). The desirable separations are specified in Table SKS 2.2.5-C.1. Using a desirable separation allows a design vehicle to complete a turning manoeuvre without encroaching on opposing traffic. Additionally, a larger separation provides sufficient distance for a vehicle to fully stop on the cross road without blocking traffic on the highway, frontage road, or opposing lane of the cross road.

The separation distances and turning wheel paths were determined using AutoTURN software and therefore may not be followed precisely in practice. Variations of entering speed, initial placement of the vehicle, and judgment and skill of the driver should be considered in the selection of an appropriate separation distance.

Notes:

- For rural roads with shoulders, some overlap of the inner wheel path over the shoulder may be tolerated.
- On very low volume facilities and where the incidence of larger vehicles is rare, some encroachment on the opposing lanes of the cross road or frontage road may be permitted and the separation distance may be reduced accordingly.
- By continuing the shoulders around the flares, traffic lanes may be delineated to sort smaller and more common vehicles using the intersection, while allowing infrequent large vehicles to use the shoulder.
On curbed streets, some clearance must be provided between the face of the curb and the edge of the wheel path of the control vehicle.

The WB-20 vehicle can turn on a tighter radius than the HSU but occupies a greater width of roadway over the middle of the turn.

### Table SKS 2.2.5-C.1 Separation Distance between Highway and Frontage Road for Design Vehicles

<table>
<thead>
<tr>
<th>Design Vehicle</th>
<th>W (m)</th>
<th>W' (m)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Minimum</td>
<td>Desirable</td>
</tr>
<tr>
<td>P</td>
<td>8</td>
<td>12</td>
</tr>
<tr>
<td>MSU</td>
<td>16</td>
<td>30</td>
</tr>
<tr>
<td>HSU</td>
<td>25</td>
<td>30</td>
</tr>
<tr>
<td>WB-20</td>
<td>30</td>
<td>60</td>
</tr>
<tr>
<td>TPD</td>
<td>65</td>
<td>100</td>
</tr>
</tbody>
</table>

- **W**: Distance between edges of lanes adjacent to outer separation
- **W'**: Distance between edge of highway lane and centreline of far median edge on the frontage road

### SKS 2.2.5-C.3 Turning and Entering Sight Distance

When there is sufficient traffic using a paired intersection, two or more vehicles may be performing turning manoeuvres simultaneously along conflicting paths. When this occurs, the effect of the separation dimension on driver performance becomes critical.

In several respects, the designer must consider the two intersections as separate entities. However, the design must provide sufficient space to enable each driver performing a turning or crossing manoeuvre to undertake the manoeuvre safely without causing conflict with other traffic using the intersections.

The critical paired manoeuvres as shown in Figure SKS 2.2.5-C.3 are as follows:

- Vehicle One making left turn off frontage road onto cross road
- Vehicle Two exiting highway and entering cross road

In the manoeuvres shown in Figure SKS 2.2.5-C.3 (a), it is frequently impossible for the driver of Vehicle One to ascertain whether a vehicle in a parallel heading on the highway is about to turn right. On many vehicles, the turn signals are not discernible from the side. Even where they are placed so as to be discernible, they may be obscured by dirt or snow or the driver may not be using the signals. Apparent speed is not a reliable criterion since the speed changes are frequently made quite rapidly over a short distance.

In addition to the above problems, the driver of Vehicle One must turn their head and part of their trunk in order to look back along the highway. This may be awkward and may be done improperly or not at all. Only after Vehicle Two has made his turn onto or driven past the cross road may the driver of Vehicle One be assured of the type of manoeuvre being made. It is therefore reasonable to provide a length of cross road separating the two intersections such that Driver One may:

- Select a suitable gap in the traffic that is on the cross road or clearly seen to be entering the cross road and then complete the manoeuvre.
- Clear the opposing traffic lane before an approaching vehicle, traveling at normal speed, can reach the point of conflict.

A very similar situation is depicted in Figure SKS 2.2.5-C.3 (b). The control dimensions suitable for the situation in Figure SKS 2.2.5-C.3 (a) will be adequate for the situation in Figure SKS 2.2.5-C.3 (b).
In determining the necessary separation distances, the following control dimensions were assumed:

- An equivalent turning radius of 23 m which would be equivalent to a 46-15-46 three-centered curve.

- Total time required for left turning vehicles on the frontage road, based on established criteria for entering (turning) sight distance at grade intersections. The times required for a left turn across a single 3.7 m traffic lane are:
  
  - 7.3 seconds for a P vehicle
  - 10.7 seconds for a SU vehicle
  - 14.0 seconds for a WB-15 vehicle
  - _____ seconds for a WB-20 vehicle

The minimum separation dimension to satisfy entering (turning) sight distance criteria for each type of vehicle in this given situation is outlined in Table SKS 2.2.5-C.2.

<table>
<thead>
<tr>
<th>Cross Road Width(^a)</th>
<th>Entering Sight Distance(^d) for 30 km/h Design Speed (m)</th>
<th>Minimum Separation Distance, W(^d) (m)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lanes</td>
<td>Width (m)</td>
<td>P</td>
</tr>
<tr>
<td>1</td>
<td>3.7</td>
<td>70</td>
</tr>
<tr>
<td>2</td>
<td>7.4</td>
<td>75</td>
</tr>
<tr>
<td>2(^b)</td>
<td>8.6</td>
<td>75</td>
</tr>
<tr>
<td>2(^c)</td>
<td>12.2</td>
<td>80</td>
</tr>
</tbody>
</table>

Notes:

\(^a\) Width to be crossed by vehicle turning from frontage road

\(^b\) Includes 1.2 metre median

\(^c\) Includes 5.0 metre median

\(^d\) Along cross road from frontage road

In this situation, drivers turning off the highway or crossing the intersections are generally alert and cautious. The turning manoeuvre requires the concentration of the driver while steering around the turn. Only after having completed the turn, is the driver free to direct his attention to other tasks. Adequate distance is required after the turn to permit him to make the necessary judgements needed to complete his manoeuvre in safety.

In the normal traffic make-up, 80%-85% of vehicles will be passenger cars. A truck turning off the frontage road, across the path of a vehicle turning from the highway onto the crossroad, presents a large image which the driver may identify quite easily. When the separation distance is based on the passenger car requirements, the distance will include adequate tangent length along the crossroad for the car driver to see the turning truck and make any necessary adjustments or stop. There is justification therefore for adopting separation dimensions adequate for passenger cars only. Adjustments in separation distances would be required in exceptional cases due to heavy truck movements resulting from the frontage road serving a weigh scale, industrial plant, freight yard, or truck depot.

**SKS 2.2.5-C.4 Traffic Control Device Space Requirements**

The layout of the intersections should be such that the driver may see, comprehend and obey the traffic signs or signals. The following factors should be considered:

- The driver should be presented with a choice of not more than two manoeuvres at any one instant
- The road or the signing should present each driving problem sequentially
A driver turning a corner is fully occupied with the task of guiding his vehicle around the corner. Only after the manoeuvre is complete should a situation requiring interpretation, decision, and a choice of action be presented to the motorist.

If the cross road is designed as secondary to the frontage road, and a stop or yield sign or traffic signal is placed to control the driver on the frontage road, the driver entering the cross road from the highway should not be confronted with a sign until he has completed his turn. In addition, the sign should be placed a distance sufficiently in advance of that point to enable the driver to get the message and comply.

A sign placed on the inside of a turn may not be visible at night because the lights are directed tangentially to the turn. Figure SKS 2.2.5-C.4 shows a common situation where the sign is not visible in adequate time due to the layout of the intersection. Figure SKS 2.2.5-C.5 shows the correct layout of the roadways and the sign.

After having reached the end of the turn, the motorist requires time to see, comprehend, and obey the sign (perception-reaction time). A perception-reaction time 2.5 s is typically used. The total distance, required to perceive a sign, react, and brake to a stop from 30 km/h is approximately 30 m. This should be normal braking (0.25g) without causing discomfort to passengers, and not panic braking (0.8g). The separation width to satisfy this criterion should therefore be not less than 55 m.

The reverse situation is quite similar (i.e. a driver turning off the frontage road and approaching the highway intersection along the cross road). Knowing that they are about to enter the highway, the motorist is aware that they should yield or stop in all cases, and may in fact do so without having seen the stop or yield sign. However, this is not a very safe assumption to use in the design. Where traffic control signs are deemed necessary, the designer should ensure that they are placed so that they are visible in an effective manner.

**SKS 2.2.5-C.5  Weaving, Merging and Capacity**

The criteria discussed previously did not incorporate provisions for heavy traffic movements. On rural highways in Saskatchewan, problems of weaving, merging, storage, and capacity will not generally be a problem. These problems often occur on major highway and street facilities within or on the fringe of the larger urban areas. On these projects, traffic needs must be analyzed and appropriately accommodated in the design.

In addition to the above design considerations other factors including turning vehicle wheel paths and sight distances must also be accommodated.

There are various options by which the operational characteristics may be improved, such as using one-way traffic on the frontage road or on the stub connector or both. These will not be discussed further since facilities of this nature must be developed on an individual basis. In urban areas, the constraints imposed by space limitations and the established road network will be a significant factor in the design solution.

**SKS 2.2.5-C.6 Ministry Standards**

As expected, experience on our very low volume facilities has shown that there is no serious problem due to the interaction of vehicles. Therefore, the main requirement is to provide adequate geometrics to permit vehicles to make the turns. Encroachment into opposing traffic lanes is tolerable providing traffic volumes are very low and encroachment occurs off the main highway.

The ministry standard takes into consideration the previously discussed controls, type of facility, traffic volumes and location (rural or urban). The standard is outlined in Standard Plan 20650.
Figure SKS 2.2.5-C.1  Minimum Separation for U-Turns

Figure SKS 2.2.5-C.2  Minimum Separation for Reverse Turns
Figure SKS 2.2.5-C.3  Manoeuvres Affecting Stopping and Entering Sight Distance at Paved Intersections
Figure SKS 2.2.5-C.4  Problems with Visibility of Signs Due to Inadequate Intersection Layout

Figure SKS 2.2.5-C.5  Minimum Spacing Required to Permit Drivers to Observe and Obey Signs