# Summary of Guidelines for Determining TS Change Clearance Intervals by ITE

## Equation for Yellow Change Interval

$$Y \geq t + \frac{1.47(V_{85} - V_E)}{a + 64.4g} + \frac{1.47V_E}{2a + 64.4g}$$

Where:

$Y$ = minimum yellow change interval (sec.);
t = perception- reaction time (sec.);
$V_{85}$ = 85th percentile approach speed (mph);
$V_E$ = intersection entry speed (mph);
$a$ = deceleration (ft./sec./sec.);
$g$ = grade of approach (percent/100, downhill is negative grade);

## Variable

1. Perception-Reaction Time, t
   ITE recommends to use 1.0 sec for the minimum perception-reaction time. However, higher value by engineering judgment may be used based on local conditions, such as, driving population age.

2. 85th Percentile Approach Speed, $V_{85}$
   a. Through Movements
      If the 85$^{th}$ percentile speed is not available, ITE recommends to use following equation for calculating the yellow change interval:

$$V_{85E}(through) = SL + 7$$

Where:

$V_{85E} = estimated\ 85th\ percentile\ speed\ (mph)$;
SL = posted speed limit (mph);

b. Turning Movements

ITE recommends to use the 85$^{th}$ percentile speed under free flow conditions as measured through a speed study. If it is not available, the speed limit should be used.

3. Intersection Entry Speed, $V_E$

ITE recommends to use the actual 85$^{th}$ percentile intersection entry speed from a speed study which measures the speed at the stop line of the intersection. If actual speed data is not available, 20 mph should be used for entry speed of turning movement.

4. Deceleration, a

ITE recommends to use $10\ ft/\sec^2$ for deceleration rate for most users. However, it may be varies based on local conditions, vehicle, type, and driving population age. Thus, the value may be modified by engineering judgment.

5. Approach Grade, g

Approach grade can be determined by field study, built design plans with field observations, and electronic and online sources. It is measured to one decimal, and negative for downgrades and positive for upgrades. If grade information is not available and it is changed over the distance, engineering judgment should be used for appropriate value.

**Other considerations**

1. Minimums and Maximums
   a. Through Movements

   The minimum value of the yellow change interval is 3.0 sec, and the maximum value is 6.0 sec. The maximum value may be modified with engineering judgment for special road conditions.

   b. Turning Movements

   The minimum value of the yellow change interval for turning movement is 3.0 sec, and the maximum value is 7.0 sec. Care must be taken when yellow change interval is greater than 6.0 sec.

2. Signal Phasing
   a. Protected-Only Left-Turn Applications

If approach speeds are greater than 40 mph, turning vehicles are not required to enter a sperate turn lane or the separate turn lane is very long, the configuration of the intersection allows for higher intersection entry speeds, particular attention should be given to selecting appropriate approach and interaction entry speeds. The maximum value is 7.0 sec.

b. Permissive-Only Left-Turn Applications

If approach speeds are greater than 40 mph, turning vehicles are not required to enter a sperate turn lane or the separate turn lane is very long, the configuration of the intersection allows for higher intersection entry speeds, particular attention should be given to selecting appropriate approach and interaction entry speeds. The maximum value is 7.0 sec. The intervals should be the same duration for the left-turn and through movements on opposing approaches to ensure that termination is concurrent.

c. Protected/Permissive Left-Turn Applications

Calculate the yellow change and red clearance intervals and implement as describes above for the respective protected and permissive portions of the phase.

d. Right-and Left-Turn Overlap Applications

If the right-turn signal terminates concurrently with an overlapping left-turn signal, the longer change intervals should be used.

e. Right-Turn Applications

The recommended approach is to calculate the through movement and left- turn movement yellow change and red clearance interval times using the approaches defined in the individual cases described above.

f. Wide Intersections

For wide intersections, engineers should define yellow change interval in the engineering practices for special consideration. 20 mph may be used for turning movements as $85^{th}$ percentile.

3. Uniformly of Intervals

If yellow change intervals are different along the arterials and in coordinated systems, apply the same value which is greater than the minimum value for the approach.

4. Rounding

   ITE recommends to round up value for yellow change interval to nearest 0.1 sec. Also, the speed of movement should be round up to the next 5mph increment.

**Equation for All Red**

$$R = \left[\frac{W + L}{1.47V_E}\right] - t_s$$

Where:

$W$ = distance to traverse the intersection (width), stop line to far side no- conflict point along the vehicle path (ft.);
$L$ = length of vehicle (ft.);
$V_E$ = intersection entry speed (mph);
$t_s$ = conflicting vehicular movement start up delay (sec.);

**Variable**

1. Width of Intersection, W

   ITE defines width of intersection as "*the total distance to traverse the distance from the stop line to the curb- line extension, or outside edge of the travel lane, of farthest conflicting vehicular movement along the vehicle's travel path.*" Also, if there are multiple lanes for turning movements, the longest turning path should be used. For frequent pedestrian traffic or pedestrian signals, the distance from the near-side stop line to include the far-side of departure crosswalk should be fully considered.

2. Vehicle Length, L

   ITE recommends to use 20ft for vehicle length. However, different vehicle lengths may be used based on engineering judgment.

3. Intersection Entry Speed, $V_E$

   ITE recommends to use the actual 85$^{th}$ percentile intersection entry speed from a speed study which measures the speed at the stop line of the intersection. If actual speed data is not available, 20 mph should be used for entry speed of turning movement.

4. Conflicting Vehicular Movement Start-Up Delay, $t_s$

   It is optional parameter with an initial value set at 0.0 sec, and it may be determined by engineering judgment or engineering study.

**Other considerations**

1. Minimums and Maximums

   A specific minimum or maximum values of the all red clearance for both through movement and turning movement is not suggested.

2. Signal Phasing

   a. Bicycle Traffic

      If roadway has separate bicycle lane, the extension of red clearance may be considered based on engineering study. The combined value of the red clearance interval and extension should not greater than 6.0 sec.

   b. Uniformly of Intervals

   If red clearance intervals are different along the arterials and in coordinated systems, apply the same value for the approach.

3. Rounding

   ITE recommends to round up value for red clearance interval to nearest 0.1 sec. Also, the speed of movement should be round up to the next 5mph increment.

# Summary of Guideline for Yellow Change Interval and All Red Clearance by SHA

## Equation for Yellow Change Interval

$$Y \geq t + \frac{1.47V}{2(a + Gg)}$$

Where:

$Y$ = minimum yellow change interval (sec.);
t = perception- reaction time (sec.);
V = velocity of approaching vehicle (mph);
$a$ = deceleration rate ($ft/s^2$).);
$g$ = grade of approach, in percent divided by 100;

## Variable

1. Perception-Reaction Time, t
   MDSHA recommends to use 1.0 sec for the minimum perception-reaction time. However, higher value by engineering judgment may be used based on local conditions, such as, driving population age.

2. Velocity of approaching vehicle
   MDSHA recommends to use the 85$^{th}$ percentile speed. However, if it is not available, it may be determined by engineering judgment. Generally, MDSHA adds 5 mph to posted speed, and it cannot be less than posted speed. If 85$^{th}$ percentile speed is less than posted speed, recommends to use posted speed for calculating yellow change interval.

3. Deceleration, a
   MDSHA recommends to use $10\ ft/\sec^2$ for deceleration rate for most users. However, if percentage of heavy vehicles is greater than 15%, $8\ ft/\sec^2$ should be used.

4. Approach Grade, g

   MDSHA recommends to adjust yellow change interval if grades are 5 percent or greater.

**Other considerations**

1. Minimums and Maximums

   The minimum value of yellow change interval is 3.5 seconds, and the maximum value should be 6.0 seconds. If the calculated yellow interval is longer than 6.0 seconds, use 6.0 seconds as yellow change interval and the remaining time should be added to the all red clearance interval.

2. Signal Phasing
   a. Left-Turn Applications

      MDSHA recommends to use same calculation for left-turn phasing as calculation for through phasing.

      If a lagging left-turn phase is used concurrently with the through, yellow change interval for both movements should be calculated and the greater value should be used.

3. Uniformly of Intervals

   If yellow change intervals are different along the arterials and in coordinated systems, apply the same value which is the highest value for the approach.

4. Rounding

   MDSHA recommends to round up to the nearest half second.

**Equation for All Red Clearance**

**Mainline**

$$AR = \frac{W + L}{1.47V} - 1$$

Where;

W = Width of the intersection (ft);

V = Velocity of approaching vehicle (mph);
L = Length of vehicle (ft);

**Side Street**

$$AR = \frac{W + L}{1.47V} - 1$$

Where;

W = Width of the intersection (ft);
V = Velocity of approaching vehicle (mph);
L = Length of vehicle (ft);

**Left Turns**

$$AR = 0.5N + A$$

Where:

N = The number of lanes opposing the left turn, N should include opposing through and right-turn lanes.
A = an adjustment of 0 to 1.0 seconds to account for wide medians and/or multiple turn lanes. Where there are wide medians (10 feet or greater) an additional 0.5 seconds should be added for every 10 feet of median width. When there are multiple left turn lanes an additional 0.5 seconds should be added. The total value of A should not exceed 1.0 seconds.

**Variable**

1. Width of intersection, W

It should be measured from the stop bar to the far edge of the furthest opposing through and right-turn lanes. If there is a crosswalk present the measurement should be from the stop bar to the near edge of the crosswalk.

2. Length of the vehicle, L
   MDSHA recommends to use 20ft for length of the vehicle.

3. Velocity of approaching vehicle, V
   MDSHA recommends to use the posted speed limit. If it is not available for side street, 25 mph or engineering judgment may be used.

**Other considerations**

1. Minimums and Maximums
   The minimum value of all red clearance shall not be less than 1.0 seconds.

2. Rounding
   MDSHA recommends to round up to the nearest half second.

## Comparison Chart for Yellow Change Interval

| | ITE | SHA |
|---|---|---|
| **Perception-Reaction Time** | 1.0 second | 1.0 second |
| **Approach speed for through movement** | 85th percentile speed, if it is not available, add 7 mph to posted speed limit. | 85th percentile speed, if it is not available, add 5 mph to posted speed limit. |
| **Approach speed for turning movement** | 85th percentile speed from a speed study, if it is not available, use the posted speed limit. | Use the same speed as mainline, but lower value may be used. Typical speed is under 30 mph. |
| **Intersection entry speed** | 85th percentile speed from a speed study, if it is not available, use 20 mph for left turn movement. | N/A |
| **Deceleration** | $10\ ft/\sec^2$ | $10\ ft/\sec^2$<br>$8\ ft/\sec^2$ if heavy vehicle is greater than 15% |
| **Minimum** | 3.0 seconds | 3.5 seconds |
| **Maximum** | 6.0 seconds for through movement<br>7.0 seconds for left turn movement | 6 seconds |
| **Uniformly of Intervals** | Use the highest value for all arterial or coordinated system. | Use the highest value for all arterial or coordinated system. |
| **Rounding** | Round up to the nearest 0.1 second. | Round up to the nearest half second. |

## Comparison Chart for All Red Clearance

| | ITE | SHA |
|---|---|---|
| **Width of intersection** | From the stop line to the curb-line extension, or outside edge of the travel lane, of farthest conflicting vehicular movement along the vehicle's travel path. | From the stop bar to the far edge of the furthest opposing through and right-turn lanes. If there is a crosswalk present the measurement should be from the stop bar to the near edge of the crosswalk. |
| **Length of vehicle** | 20 ft | 20 ft |
| **Approach speed** | N/A | Use posted speed, if it is not available for side street, use 25 mph or engineering judgement. |
| **Intersection entry speed** | $85^{th}$ percentile speed from a speed study, if it is not available, use 20 mph for left turn movement. | N/A |
| **Conflicting vehicular movement start up delay** | Optional parameter with an initial value set at 0.0 sec, and it may be determined by engineering judgment or engineering study. | N/A |
| **The number of lanes opposing the left turn** | N/A | For left turn movement, it should include opposing through and right-turn lanes |

| | | |
|---|---|---|
| **An adjustment to account for wide medians and/or multiple turn lanes** | N/A | For left turn movement. 0 to 1.0 sec adjustment. |
| **Minimum** | N/A | 1 second. |
| **Maximum** | N/A | N/A |