NCHRP

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NATIONAL COOPERATIVE HIGHWAY RESEARCH PROGRAM

Guidelines for Timing Yellow and All-Red Intervals at Signalized Intersections

TRANSPORTATION RESEARCH BOARD
OF THE NATIONAL ACADEMIES

APPENDIX A

Guidelines for Timing Yellow and All-Red Intervals at Signalized Intersections

BACKGROUND

The yellow change interval is the period of time following the green signal indication during which a yellow signal indication is displayed. The red clearance interval is the period of time that follows the yellow signal indication during which a red signal indication is displayed to all conflicting movements at an intersection. The yellow change interval and red clearance interval are collectively referred to as the change interval.

The purpose of the yellow change interval is to warn drivers of an impending change in the right-of-way assignment. The purpose of the red clearance interval is to provide additional time as a safety factor for a driver that legally entered the intersection at the very last instant of the yellow change interval to avoid conflict with traffic releasing from an adjacent opposing intersection approach.

CHANGE INTERVAL CALCULATION

The yellow change and red clearance intervals are calculated using the equations and associated parameters as presented in the following sections.

Yellow Change Interval

The yellow change interval (Y) is calculated using Equation A:

$$Y = t + \frac{1.47V}{2a+64.4g} \qquad \textbf{Equation A}$$

Where:

- t = PRT (s); *set at 1.0 seconds*
- a = deceleration rate (ft/s^2); *set at 10 ft/s^2*
- V = 85th percentile approach speed (mph)
- g = approach grade (percent divided by 100, negative for downgrade)

The value recommended for PRT (t) is 1.0 second and for deceleration rate (a) is 10 ft/s^2. The value for the approach speed (V) is recommended as the 85th percentile speed determined under free-flow conditions. If the 85th percentile approach speed is available, then the yellow change interval is calculated

directly from Equation A. Since the 85th percentile speed is typically not available, it can be assumed as the posted speed limit plus 7 mph, except for left-turn movements (as explained). Table A provides yellow change intervals for through movements based on typical roadway and driver conditions assuming the posted speed limit plus 7 mph for grades in the range of ±4 percent.

Table A. Yellow Change Interval (seconds) by Approach Speed Limit and Grade

Posted Speed Limit (mph)*	Grade (%)				
	-4	-2	0	2	4
25	3.7	3.5	3.4	3.2	3.1
30	4.1	3.9	3.7	3.6	3.4
35	4.5	4.3	4.1	3.9	3.7
40	5.0	4.7	4.5	4.2	4.1
45	5.4	5.1	4.8	4.6	4.4
50	5.8	5.5	5.2	4.9	4.7
55	6.2	5.9	5.6	5.3	5.0

*Yellow change intervals calculated using 85th percentile approach speed estimation of posted speed limit +7 mph

Red Clearance Interval

The red clearance interval (R) is calculated using Equation B:

$$R = \frac{W+L}{1.47V} - 1 \qquad \textbf{Equation B}$$

Where:

W = intersection width measured from the back/upstream edge of the approaching movement stop line to the far side of the intersection as defined by the extension of the curb line or outside edge of the farthest travel lane (ft)

L = length of vehicle (ft); *set at 20 feet*

V = 85th percentile approach speed (mph)

The width of the intersection (W) should be measured from the back/upstream edge of the stop line to the far-side intersection limit as determined by the extension of the curb line or outside edge of the farthest travel lane. A pedestrian crossing equipped with pedestrian signals on a receiving lane should not be considered unless the nearest crossing line is 40 feet or more from the extension of the farthest edge of the farthest conflicting traffic lane. If this condition exists, the intersection width should be measured from the back/upstream edge of the approaching movement stop line to the nearest pedestrian crossing line. The length of the vehicle (L) should be assumed as 20 feet. The same approach speed value used to calculate the yellow change interval should be used to calculate the red clearance interval, except for left-turn movements (as explained). The reduction of 1 second is to account for the start-up delay typically incurred by a driver stopped on a conflicting approach to react to a green signal indication and proceed forward.

The following provisions apply for specifying the duration of a calculated red clearance interval:

- If the calculated red clearance interval is less than or equal to 1.0 seconds, then the minimum implemented duration should be 1.0 seconds.

- If the calculated red clearance interval is greater than 1.0 seconds, then the implemented duration should be as calculated.

For Left-Turn Movements

Yellow change and red clearance intervals for left-turn movements should be calculated using Equations A and B with the following modified parameters:

Yellow Change Interval

V = approach speed (mph); *should be set at the approach speed limit minus 5 mph*

Red Clearance Interval

W = length of the approaching vehicle turning path measured from the back/upstream edge of the approaching movement stop line to the far side of the intersection as defined by the extension of the curb line or outside edge of the farthest travel lane (ft)*

V = approach speed (mph); *should be set at 20 mph regardless of the approach speed limit*

*A pedestrian crossing equipped with pedestrian signals on a receiving lane should not be considered unless the nearest crossing line is 40 feet or more from the extension of the farthest edge of the farthest conflicting traffic lane. If this condition exists, the intersection width should be measured from the back/upstream edge of the approaching movement stop line to the nearest pedestrian crossing line.

When calculating yellow change and red clearance intervals for left-turning vehicles, signal phasing should be considered as follows:

- For protected-only left-turn movements, the yellow and red intervals shall be calculated for each approach and implemented as calculated. The intervals do not have to be the same duration for opposing approaches.
- For permissive-only left-turn movements, the yellow and red intervals shall be calculated for opposing approaches, including the through movements. The implemented intervals shall be the longest of the calculated values (left, through, or combination). The intervals shall be the same duration for the left-turn and through movements on opposing approaches to ensure that termination is concurrent.
- For protected/permissive left-turn movements, the yellow and red intervals shall be calculated and implemented as described above for the respective protected and permissive portions of the phase.

OTHER CONSIDERATIONS

Grade Measurement

If a measurement of approach grade is required, as a general rule, it should be taken at the distance corresponding to the upper boundary of the dilemma zone (i.e., approximately 5.0 seconds upstream of the stop line) based on the approach speed limit plus 7 mph.

Unusual Conditions

While the guidelines are based on typical roadway and driver conditions, there may be instances when exceptions are necessary to accommodate unusual conditions. Under these circumstances, the engineer or practitioner may exercise "engineering judgment" to determine that the conditions warrant the use of other calculation or implementation practices than those presented in the guideline. However, under typical roadway and driver conditions, drivers should expect that the duration of the yellow change and red clearance intervals will be calculated according to the recommended kinematic equation and its associated recommended values.

Rounding

Modern digital traffic signal controllers are capable of programming values to one-tenth of a second (0.1 s) for any interval; therefore, the timings for the yellow change and red clearance intervals can be calculated in tenths of a second. Using Equations A and B to calculate the yellow change and red clearance interval durations, the resulting values should be rounded to the nearest 0.1 seconds. Values ending in 0.01 to 0.04 should be rounded down to the nearest tenth of a second whereas values ending in 0.05 to 0.09 should be rounded up to the nearest tenth of a second.

If an existing agency policy rounds change interval values to the nearest half-second (0.5 s), then the following methodology is suggested:

- Values ending in 0.0 to 0.1 should be rounded down to the nearest whole number;
- Values ending in 0.2, 0.3, and 0.4 should be rounded up to the half-second;
- Values ending in 0.6 should rounded down to the half-second; and,
- Values ending in 0.7, 0.8, and 0.9 should be rounded up to the nearest whole number.