
**City of El Mirage
Traffic Signal Timing Policy
Date of Approval: April 23, 2014**

The Manual on Uniform Traffic Control Devices (MUTCD) 2009 Edition, and the Arizona Supplemental modifications, dated January 13, 2012, as adopted by the Arizona Department of Transportation as a standard for traffic control devices for use upon the streets and highways of the State of Arizona, serves as the general basis for the design and operations of the traffic signals owned and maintained by the City of El Mirage.

The following Traffic Signal Timing Policy is intended to conform to the requirements of the 2009 MUTCD and comply with the mandated requirements set forth in Table I-2 by the Federal Highway Administration requiring that the yellow change and red clearance intervals shall be determined using engineering practices, and that pedestrian change intervals not extend into the red clearance interval, and shall be followed by a buffer interval of at least 3 seconds.

This policy shall apply to all calculations of yellow change (yellow) and red clearance (all-red) timing, for permissive and protected-only movements, and WALK and DON'T WALK intervals. These formulae shall be utilized for all applicable signal phase change interval calculations performed on City of El Mirage traffic signals after the date of approval of this policy.

Vehicle Change and Clearance Intervals - Permissive Phases:

Vehicle phase change and clearance intervals are intended to provide a uniform and orderly transition between two conflicting phases. They consist of a yellow change interval and a red clearance interval.

The yellow vehicle change interval shall always be followed by an all-red clearance interval of sufficient duration to permit the intersection to clear, before cross traffic is released. The length of the yellow vehicle change interval and the all-red clearance interval shall be established on the basis of these guidelines and engineering judgment of an experienced traffic signal practitioner.

The City of El Mirage uses Institute of Transportation Engineers (ITE) formulas for phase change intervals. These formulas are general and should be used as a guide. Other factors at an intersection, such as approach grades, visibility, percentage of truck traffic and local traffic characteristics, should be considered. It is important that approach grades and truck traffic are considered in determining the yellow and red intervals. The yellow change interval must not be too short (causing quick stops and/or red violations) nor too long (encouraging vehicles to enter late in the yellow interval).

An engineering study may be used to determine the 85th percentile approach speed. The posted speed limit may be assumed to be the approach speed (v), when an engineering study is not available.

Yellow Change Interval - Permissive Phase:

The exclusive function of the yellow change interval shall be to warn traffic of an impending change in the right-of-way assignment. Yellow vehicle change intervals should have a range of 3.0 to 6.0 seconds.

The following formulas are used to determine the yellow time. This is based on the Institute of Transportation Engineers equation for yellow change interval.

$$\text{Min Yellow Vehicle Change Interval (Permissive movement)} = t_1 + t_2$$

$$\text{Reaction time } (t_1) = 1 \text{ sec}$$

$$\text{Deceleration time } (t_2) = \frac{1.47 v}{(2a + 64.4g)}$$

Where, v = 85th percentile approach speed (from a study) or posted speed limit (mph); for protected-permitted left turn movements, assume 25 mph
 g = % grade, divided by 100 (downhill is negative grade)
 a = assumed typical deceleration rate of 10 ft/sec/sec

Experience has shown that a perception-reaction time (t_1) of one second (1 sec) is realistic. Also, deceleration rates of 8 and 12 feet per second per second are the lower and upper limits for establishing vehicle change intervals. For typical applications, a deceleration rate (a) of 10 feet per second per second is used in calculating the yellow vehicle change interval. Assuming a deceleration rate of 10 feet per second per second, on a flat approach, the above formulas result in the following values for minimum yellow vehicle change intervals:

Approach Speed or Posted Speed Limit (mph)	Minimum Yellow Vehicle Change Interval (sec)
15	3.0
20	3.0
25	3.0
30	3.2
35	3.6
40	3.9
45	4.3
50	4.7
55	5.0
60	5.4
65	5.8

Red Clearance Interval - Permissive Phase:

The red clearance interval is an interval at the end of the yellow change interval, during which the phase has a red-signal display before the display of green for the next phase. Although not required by the MUTCD, the City of El Mirage provides this interval to provide additional time before conflicting traffic movements are released.

The range of values for the red clearance interval shall be from a minimum of 1.0 second to a maximum of 6.0 seconds.

The following formula is used to determine the red clearance interval time, based on the Institute of Transportation Engineers (ITE) equation for the red clearance interval.

$$\text{Red Clearance Interval } (t_3) = \frac{W + L}{1.47 v}$$

- Where, v = 85th percentile approach speed (from a study), or posted speed limit (mph)
- W = Intersection width (ft), from stop line to projection of the farthest conflicting lane's right-side edge line or curb line
- L = Length of typical vehicle (ft), assumed to typically be 20 feet

Locations that provide an exclusive right turn lane should consider the last conflicting thru lane as the farthest conflicting lane when determining the intersection width.

Vehicle Change and Clearance Intervals - Protected-Only Left Turns:

The following procedures apply only to protected-only left turns, where left turn maneuvers from an approach are limited to being performed only during the display of a green left turn arrow, are not allowed during the display of a green ball for the adjacent thru traffic, and are otherwise prohibited by the display of a red left arrow.

Yellow Change Interval - Protected-Only Left Turns:

The following formula is used to determine the yellow time. This is based on the Institute of Transportation Engineers equation for yellow change interval.

$$\text{Min Yellow Vehicle Change Interval (Protected-Only movement)} = t_1 + t_2$$

Reaction time (t_1) = 1 sec

$$\text{Deceleration time } (t_2) = \frac{1.47 v}{(2a + 64.4g)}$$

- Where, v = 85th percentile approach speed (from a study) or assume 25 mph
- g = % grade, divided by 100 (downhill is negative grade)
- a = assumed typical deceleration rate of 10 ft/sec/sec

Combining all of the typical conditions and values, in the absence of any valid engineering study providing contrary data, the calculation yields a numeric value of 2.8 seconds. Noting the requirement that the minimum any yellow interval may be is 3.0 seconds, the typical value of a minimum yellow change interval for a protected-only left turn phase should therefore be 3.0 seconds, unless valid engineering study data shows that typical speeds or deceleration rates are proven to be different at a field site, and the application of engineering judgment suggests higher values.

Red Clearance Interval - Protected-Only Left Turns:

Although not required by the MUTCD, the City of El Mirage provides this interval to provide additional time before conflicting traffic movements are released.

The range of values for the red clearance interval shall be from a minimum of 1.0 second to a maximum of 6.0 seconds.

The following formula is used to determine the red clearance interval time, based on the Institute of Transportation Engineers (ITE) equation for the red clearance interval.

$$\text{Red Clearance Interval (Protected Left) } (t_3) = \frac{W + L}{1.47 v}$$

Where, v = 85th percentile approach speed (from a study) or assume 25 mph
 W = Travel distance of left turning vehicle, in feet, measured in a straight line chord from the point where the near-side stop line intersects the outermost left turn lane line, directly to the point where the extension of the outside edge of the receiving lane for the outermost turning movement intersects the extension of the outside edge of the outermost conflicting traffic lane's right-side edge line or curb line
 L = Length of typical vehicle (ft), assumed to typically be 20 feet

Locations that provide an exclusive right turn lane should consider the last conflicting thru lane as the farthest conflicting lane when determining the intersection width.

Pedestrian Intervals:

WALK:

The WALK indication should be at least 7 seconds in length so that pedestrians will have adequate opportunity to leave the curb or wheelchair ramp before their clearance interval is shown. A WALK interval of more than 7 seconds may be used if justified by observation of quantity and type of pedestrian mix causing a justified need for additional WALK time.

DON'T WALK:

A flashing DON'T WALK indication shall always succeed the WALK indication to provide pedestrian clearance. The pedestrian clearance time shall be calculated from the following equation:

$$\text{DON'T WALK} = \frac{P}{w} \quad (\text{Rounded up to next whole second})$$

Where, P = distance from curb to curb (or depressed curb, where sidewalk ramps are provided), along the center of the crosswalk, in feet
 w = walking speed, assumed to be 3.5 ft/sec

On a street which has an ADA compliant pedestrian refuge island, or median of 6 feet or greater width, the pedestrian clearance time may be computed to provide only enough time to clear the crossing from the curb to the median; in such cases, an additional detector shall be provided on the island.