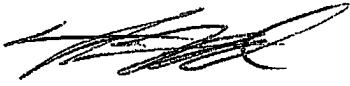



CITY OF VENTURA  
**PUBLIC WORKS**

*"Preserving Ventura's vital infrastructure and environment"*

**STANDARD OPERATING PROCEDURE NO. 33.22**

<b>Subject: TRAFFIC SIGNAL CLEARANCE INTERVALS</b>	
<b>Issued by:</b> Thomas Mericle, Transportation Manager 	<b>Approved by:</b> Rick Raives, Public Works Director 
<b>Date Issued: February 2, 2009</b>	<b>Division: Transportation</b>
<b>Review/Update Frequency: As needed</b>	<b>Date of this Revision:</b> February 23, 2015; Thomas Mericle, Transportation Manager

**Purpose**

The purpose of this SOP is to establish a procedure for determining the length of clearance intervals at signalized intersections.

**Safety Precautions**

Traffic signal clearance timing allows for safe use of traffic signalized intersections by drivers because it allows for a decision making process and measure of safety at the termination of the green light phase.

**Procedure**

A. GENERAL

With the passage of AB 1022 the California Vehicle Code (CVC) was amended to include Section 21455.7 (a). This new section required agencies employing automated enforcement programs to establish minimum yellow light change intervals in accordance with the Traffic Manual of the

Department of Transportation. California's Department of Transportation (Caltrans) adopted traffic manual is the California Manual of Uniform Traffic Control Devices (CAMUTCD).

This policy documents the City's methodologies in determining the length of the yellow light change interval in compliance with State law. Since the City has established the use of the all-red change interval, this policy also documents the methodology in determining the length of the all-red time.

As documented in the CAMUTCD, "the purpose of the yellow signal indication is to warn traffic approaching a traffic signal that the related green movement is ending or that a steady red indication will be exhibited immediately thereafter and traffic will be required to stop when the red signal is exhibited.

The function of the all-red clearance interval during the operation of a traffic signal is to partially or fully clear the intersection of vehicles that have entered during the yellow interval.

It should be noted that signal timing at signalized intersections jointly maintained by the City and the State is determined by Caltrans. This includes the clearance intervals.

## B. GUIDELINES FOR DETERMINING YELLOW CHANGE INTERVALS

As indicated in Section 4D.26 of the CAMUTCD, "The minimum yellow change interval for through traffic movement shall be determined by using the 85<sup>th</sup> percentile speed of free-flow traffic rounded up to the next 5 mph increment. Where the posted or prima facie speed limit is higher than the rounded value, use the posted or prima facie speed limit for determination of the minimum yellow change interval for the through traffic movement. See Table 4D-102 (a)". CAMUTCD Section 4D.26 goes on to say, "If the 85<sup>th</sup> percentile speed data is not available, the minimum yellow change interval for through traffic movements shall be determined by adding 7 miles per hour to the posted or prima facie speed limits of 30 mph or higher, and by adding 10 miles per hour to the posted or prima facie speed limits of 25 mph or less. See Table 4D-102 (b)".

**TABLE 4D-102 (a)**

<b>SPEED (Determined by 85<sup>th</sup> Percentile Speed) MPH</b>	<b>Yellow Interval (seconds)</b>
25 or less	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

**TABLE 4D-102 (b)**

<b>POSTED SPEED or UNPOSTED PRIMA FACIE SPEED* (MPH)</b>	<b>MINIMUM YELLOW INTERVAL (SECONDS)</b>	<b>MINIMUM YELLOW INTERVAL (SECONDS)</b>
15	N/A	3.0
20	N/A	3.2
25	N/A	3.6
30	3.7	N/A
35	4.1	N/A
40	4.4	N/A
45	4.8	N/A
50	5.2	N/A
55	5.5	N/A
60 or higher	5.9	N/A

\* Speed values are inclusive of the 7 mph added for speeds equal to 30 mph or higher and 10 mph for speeds equal to or lower than 25 mph for determining the minimum values of the yellow intervals.

In order to be the most conservative in setting yellow clearance times, the City will check Tables 4D-102 (a) and (b), the yellow change interval will be set to the interval with the longest clearance time. For example, if the current E&T Survey for a street segment indicates an 85<sup>th</sup> percentile speed of 41 mph and the resulting posted speed is set at 35 mph, the yellow light change interval time could be either 4.3 seconds according to Table (a) or 4.1 seconds according to Table (b). In this situation, 4.3 seconds would be used as the yellow clearance interval.

Regarding protected left and right turns, the CAMUTCD gives minimal guidance on setting the yellow time change interval. However, the CAMUTCD indicates that, "particular attention should be paid where setting minimum yellow change interval timing when exclusive turn lane exceeds 150 feet in length excluding the transition". The CAMUTCD also indicates that, "the minimum yellow change interval for the through movement and the protected left-turn may be increased based on appropriate engineering judgement".

The minimum yellow change interval for any approach including protected left and right turns will be 3.6 seconds. This yellow change interval coincides with the minimum yellow interval for streets with a prima facia speed limit of 25 mph from Table 4D-102 (b). Increase in this time can be done in special circumstances at the approval of the City Transportation Manager.

Since overlap protected right turns have a yellow time change interval the same as the associated protected left turn, by default, the yellow time will match the left turn amount. This amount of change interval time is appropriate, as the safe and reasonable vehicle speed prior to making a right turn is less than or equal to the vehicle speed prior to making a left turn.

### C. GUIDELINES FOR DETERMINING ALL-RED CHANGE INTERVALS

The CAMUTCD indicates that all-red intervals normally range between 0.1 second to 2.0 seconds. However, it does not give any guidance as to how to determine the length of the interval. Review of the Institute of Transportation Engineers (ITE) standards <sup>(1)</sup> indicated that an appropriate all-red change interval can be calculated through the use of the following formula:

$$R = \frac{W + V}{S}$$

where:

S = 85<sup>th</sup> percentile speed, (ft/s)

W = Width of intersection from near side stop line to end of far side crosswalk, (ft)

V = Length of vehicle, (V = 15ft)

R = Red clearance interval (s)

Therefore, using the above formula, signal phases associated with through movements shall have all-red change intervals based on the table shown below:

85 <sup>th</sup> Percentile speed, (mph)	Red Clearance Interval, (seconds), for Width of Intersection, (feet)								
	40	60	80	100	120	140	160	180	200
15	2.5	3.4	4.3	5.2	6.1	7.0	8.0	8.9	9.8
20	1.9	2.6	3.2	3.9	4.6	5.3	6.0	6.7	7.3
25	1.5	2.0	2.6	3.1	3.7	4.2	4.8	5.3	5.9
30	1.3	1.7	2.2	2.6	3.1	3.5	4.0	4.4	4.9
35	1.1	1.5	1.8	2.2	2.6	3.0	3.4	3.8	4.2
40	0.9	1.3	1.6	2.0	2.3	2.6	3.0	3.3	3.7
45	0.8	1.1	1.4	1.7	2.0	2.3	2.7	3.0	3.3
50	0.8	0.9	1.3	1.6	1.8	2.1	2.4	2.7	2.9
55	0.7	0.9	1.2	1.4	1.7	1.9	2.2	2.4	2.7
60	0.6	0.8	1.1	1.3	1.5	1.8	2.0	2.2	2.4

Note: Shaded intervals are >2.0 seconds and shall not be used.

All-red clearance intervals will not be set any higher than 2.0 seconds. Long all-red clearance intervals have a significant impact on the operation of traffic signals, may result in increased red light running and are not consistent with motorists' expectations of the operation of a traffic signal.

For signal phases associated with left turns, the all-red change interval will initially be set at 1.0 second. However, adjustments can be made to correspond with conditions at specific locations. Adjustments to change intervals may be made based on the geometry of an intersection, field observations, 85<sup>th</sup> percentile speed within the intersection or other factor(s) that could contribute to the variation in the all-red change interval.

In the past, city-wide all-red times were generally set at 2.0 seconds for through movements. Based on the all-red change interval table above, the calculated all-red times may need to be shorter than the timing intervals set prior to adoption of this policy. Since motorists have been conditioned to expect a certain amount of all-red time, any changes that will be made will be done at 0.2 second intervals over an extended period of time until the calculated change interval is attained.

### **Definitions**

None

### **References**

- (1) Institute of Transportation Engineers, *Traffic Control Devices Handbook, 2001.*

**C. If the approach has one or more exclusive turn lanes in addition to the shared left-turn/right-turn lane and there is a conflict with a signalized vehicular or pedestrian movement, and flashing YELLOW ARROW signal indications are used in place of CIRCULAR GREEN signal indications on the approach, the signal faces for the approach shall be as described in Items B.1 and B.2, except that flashing YELLOW ARROW signal indications shall be used in place of the GREEN ARROW signal indications for the turning movement(s) that conflicts with the signalized vehicular or pedestrian movement.**

**Support:**

<sup>05</sup> Figure 4D-20 illustrates application of these Standards on approaches that have only a shared left-turn/right-turn lane, and on approaches that have one or more exclusive turn lanes in addition to the shared left-turn/right-turn lane.

**Option:**

<sup>06</sup> If the lane-use regulations on an approach are variable such that at certain times all of the lanes on the approach are designated as exclusive turn lanes and no lane is designated as a shared left-turn/right-turn lane:

- A. During the times that no lane is designated as a shared left-turn/right-turn lane, the left-turn and right-turn movements may start and terminate independently, and the left-turn and right-turn movements may be operated in one or more of the modes of operation as described in Sections 4D.17 through 4D.24; and
- B. If a protected-permissive mode is used, the shared left-turn/right-turn signal face provided in Paragraph 4 may be modified to include a dual-arrow signal section capable of displaying both a GREEN ARROW signal indication and a flashing YELLOW ARROW signal indication for a turn movement(s) in order to not exceed the maximum of five sections per signal face provided in Section 4D.08.

**Section 4D.26 Yellow Change and Red Clearance Intervals**

**Standard:**

<sup>01</sup> A steady yellow signal indication shall be displayed following every CIRCULAR GREEN or GREEN ARROW signal indication and following every flashing YELLOW ARROW or flashing RED ARROW signal indication displayed as a part of a steady mode operation. This requirement shall not apply when a CIRCULAR GREEN, a flashing YELLOW ARROW, or a flashing RED ARROW signal indication is followed immediately by a GREEN ARROW signal indication.

<sup>02</sup> The exclusive function of the yellow change interval shall be to warn traffic of an impending change in the right-of-way assignment.

<sup>03</sup> The duration of the yellow change interval shall be determined using engineering practices.

**Support:**

<sup>04</sup> Section 4D.05 contains provisions regarding the display of steady CIRCULAR YELLOW signal indications to approaches from which drivers are allowed to make permissive left turns.

**Guidance:**

<sup>05</sup> *When indicated by the application of engineering practices, the yellow change interval should be followed by a red clearance interval to provide additional time before conflicting traffic movements, including pedestrians, are released.*

**Standard:**

<sup>06</sup> When used, the duration of the red clearance interval shall be determined using engineering practices.

**Support:**

<sup>07</sup> Engineering practices for determining the duration of yellow change and red clearance intervals can be found in ITE's "Traffic Control Devices Handbook" and in ITE's "Manual of Traffic Signal Design" (see Section 1A.11).

**Standard:**

<sup>08</sup> The durations of yellow change intervals and red clearance intervals shall be consistent with the determined values within the technical capabilities of the controller unit.

<sup>09</sup> The duration of a yellow change interval shall not vary on a cycle-by-cycle basis within the same signal timing plan.

<sup>10</sup> Except as provided in Paragraph 12, the duration of a red clearance interval shall not be decreased or omitted on a cycle-by-cycle basis within the same signal timing plan.

**Option:**

11 The duration of a red clearance interval may be extended from its predetermined value for a given cycle based upon the detection of a vehicle that is predicted to violate the red signal indication.

12 When an actuated signal sequence includes a signal phase for permissive/protected (lagging) left-turn movements in both directions, the red clearance interval may be shown during those cycles when the lagging left-turn signal phase is skipped and may be omitted during those cycles when the lagging left-turn signal phase is shown.

13 The duration of a yellow change interval or a red clearance interval may be different in different signal timing plans for the same controller unit.

**Guidance:**

14 *A yellow change interval should have a minimum duration of 3 seconds and a maximum duration of 6 seconds. The longer intervals should be reserved for use on approaches with higher speeds. Practitioners should exercise engineering judgment for determination of the minimum yellow change interval. Judgment should be based on numerous factors including, but not limited to, field observation of traffic behavior, intersection geometrics, downhill grade, perception-reaction time of drivers in the area, and actually driving the protected left-turn or protected right-turn movements to assess the need for longer yellow change intervals. Particular attention should be paid where setting minimum yellow change interval timing when exclusive turn lane exceeds 150 feet in length excluding the transition. Refer to Table 4D-102(CA).*

**Support:**

14a The purpose of the yellow signal indication is to warn traffic approaching a traffic signal that the related green movement is ending or that a steady red indication will be exhibited immediately thereafter and traffic will be required to stop when the red signal is exhibited.

**Standard:**

14b **The minimum yellow change interval for through traffic movement shall be determined by using the 85th percentile speed of free-flow traffic rounded up to the next 5 mph increment. Where the posted or prima facie speed limit is higher than the rounded value, use the posted or prima facie speed limit for determination of the minimum yellow change interval for the through traffic movement. See Table 4D-102(CA) sub-heading "a".**

14c **If the 85th percentile speed data is not available, the minimum yellow change interval for through traffic movements shall be determined by adding 7 miles per hour to the posted or prima facie speed limits of 30 mph or higher, and by adding 10 miles per hour to the posted or prima facie speed limits of 25 mph or less. See Table 4D-102(CA) sub-heading "b".**

**Option:**

14d The minimum yellow change interval for the through movement and the protected left-turn or protected right-turn may be increased based on appropriate engineering judgment.

15 *Except when clearing a one-lane, two-way facility (see Section 4H.02) or when clearing an exceptionally wide intersection, a red clearance interval should have a duration not exceeding 6 seconds.*

**Support:**

15a When used, red clearance intervals normally range from 0.1 to 2.0 seconds.

**Standard:**

16 **Except for warning beacons mounted on advance warning signs on the approach to a signalized location (see Section 2C.36), signal displays that are intended to provide a "pre-yellow warning" interval, such as flashing green signal indications, vehicular countdown displays, or other similar displays, shall not be used at a signalized location.**

**Support:**

17 The use of signal displays (other than warning beacons mounted on advance warning signs) that convey a "pre-yellow warning" have been found by research to increase the frequency of crashes.

**Table 4D-102 (CA). Minimum Yellow Change Interval Timing**

$$\text{Yellow Time} = \frac{\text{Detector Setback Distance}}{\text{Speed}}$$

$$T = \frac{D}{V} = \text{The minimum yellow change interval (sec)}$$

V = Speed (ft/sec)

d = Deceleration Rate (10 ft/sec<sup>2</sup>)

t<sub>R</sub> = Reaction Time (1 sec)

Reaction Distance = Vt<sub>R</sub>

Deceleration Distance =  $\frac{1}{2}dt^2$  or  $\frac{1}{2}Vt$  or  $\frac{V^2}{2d}$

D = Detector Setback = Deceleration Distance + Reaction Distance =  $\frac{V^2}{2d} + Vt_R$

$$T = \frac{\frac{V^2}{2d} + Vt_R}{V}$$

$$T = \frac{V}{2d} + t_R$$

**a - For Speed determined by 85th Percentile**

SPEED (Determined by 85th Percentile Speed)*	MINIMUM YELLOW INTERVAL
mph	Seconds
25 or less	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

\*See Section 4D.26 Standard under paragraph 14b

**b - For Posted or Prima Facie Speed**

POSTED SPEED or UNPOSTED PRIMA FACIE SPEED	MINIMUM YELLOW INTERVAL*	MINIMUM YELLOW INTERVAL*
mph	Seconds	Seconds
15	N/A	3.0
20	N/A	3.2
25	N/A	3.6
30	3.7	N/A
35	4.1	N/A
40	4.4	N/A
45	4.8	N/A
50	5.2	N/A
55	5.5	N/A
60 or higher	5.9	N/A

\*Speed values for Table 4D-102b (CA) are inclusive of the 7 MPH added for speeds equal to 30 MPH or higher and 10 MPH for speeds equal to or lower than 25 MPH for determining the minimum values of the yellow intervals.