An Informational Report of the
Institute of Transportation Engineers

Determining Vehicle Signal Change and Clearance Intervals

Prepared by ITE Technical Council Task Force 4TF-1

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This report is an Informational Report of the Institute of Transportation Engineers prepared by Technical Council Task Force 4TF-1. The information in this report has been obtained from experiences of transportation engineering professionals and research. ITE Informational Reports are prepared for informational purposes only and do not include Institute recommendations on the best course of action or the preferred application of data.

The objective of Task Force 4TF-1 was to present some of the various methods used to determine vehicle signal change intervals so as to provide traffic engineers with a variety of viable alternatives. This report does not constitute a Recommended Practice and is not intended to provide the only methods for determining the lengths of yellow change intervals or red clearance intervals; it focuses on current U.S. practices and contains information on particular procedures.

Committee 4TF-1 was chaired by Beverly A. Thompson (A). Other members of Committee 4TF-1 were Howard H. Bissell, P.E. (FL); Harold P. Garfield, P.E. (F); Steven G. Jewell, P.E. (F); David W. McKinley (M); Stan Teply, P.E. (F); Warren A. Tighe, P.E. (M); and Robert H. Wortman, P.E. (M).

Members of the Department 4 Standing Committee at the time the report was approved were: Kay Fitzpatrick, P.E. (M), Chair; Jeffrey F. Paniati, P.E. (A), Asst. Chair; Brian E. Hicks, P. E. (M); William C. Kloos, P.E. (M); Edward J. Seymour, P.E. (A); David E. Woosley, P.E. (F); Donna C. Nelson (A); Deborah L. Seneca, P.E. (A); and Hart L. Solomon, P.E. (F). Brian S. Bochner, P.E. (F), was the Chair of Technical Council, and John M. Mason, P.E. (F), was the Assistant Chair.

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Introduction

THE OBJECTIVE OF ITE TECHNICAL COUNCIL TASK Force 4TF-1 was to present some of the various methods used to determine vehicle signal change interval lengths so as to provide traffic engineers with a variety of viable alternatives. A variety of methods based on differing philosophies and formulas are presented, indicating that positions and practices vary significantly regarding vehicle signal change interval timing.

The methodologies presented in this report are based on the "permissive yellow rule," which allows drivers to enter the intersection until the end of the yellow interval. Some jurisdictions use one of two "restrictive yellow rules," which state that drivers either (1) may not enter on yellow unless they can clear the intersection before the end of the yellow interval, or (2) may not enter on yellow unless it is impossible or unsafe to stop. Rule 2 is generally not in conflict with the "permissive yellow rule."

For this report, the term "vehicle signal change interval" (also known as the intergreen period in Canada, Australia, United Kingdom and elsewhere) is defined as that period of time in a traffic signal cycle between conflicting green intervals, and is characterized by a yellow change interval sometimes followed by a red clearance interval. The yellow change interval tells an approaching driver that the right-of-way is about to be assigned to a conflicting traffic flow. In some locales, a red clearance interval is used to provide additional time for drivers to clear the intersection before the green indication is displayed to conflicting traffic.

Divergent and strongly held positions are common when vehicle signal change interval lengths are discussed. Some believe that a uniform yellow change interval length is best, while others believe that uniform yellow change interval lengths are wrong and even dangerous. Some designers use elaborate timing procedures, while others use simple rule-of-thumb methods, a single uniform time interval, or use an interval length based solely on engineering.

This report focuses on current U.S. practices and contains information on particular procedures. A previous report describing the deliberations held before the writing of this Informational Report, titled *Determining Vehicle Change Intervals—A Proposed Recommended Practice,* is available from the ITE Bookstore (Publ. No. RP-016, $5 members/$10 nonmembers).

Editor's Note: Because of the lack of consensus in this technical area, the Technical Council decided to prepare an Informational Report on this subject presenting several alternatives, rather than a Recommended Practice presenting only one alternative.

Definitions

THE DEFINITIONS PRESENTED BELOW ARE FROM THE *Uniform Vehicle Code*[1] and the *Manual on Uniform Traffic Control Devices*[2] (MUTCD), except as noted. Most states have laws that conform to the definitions in these two documents. However, because every state differs and not all conform, the following definitions do not necessarily apply universally.

Green Indication. Vehicular traffic facing a circular green indication may proceed straight through the intersection, or turn right or left as allowed by opposing traffic, except when such movements are restricted by lane use signs, turn prohibition signs, lane markings or geometric design of the roadway. Vehicles facing a green arrow indication (shown alone or in combination with another indication), may enter the intersection to make a movement indicated by such arrow or permitted by other indications shown at the same time. Vehicular traffic, including vehicles turning right or left, shall yield the right-of-way to other vehicles and pedestrians legally within the intersection or an adjacent crosswalk at the time such signal indication is exhibited.

Yellow Indication. Vehicular traffic facing a steady circular yellow or yellow arrow indication is thereby warned that the related green movement is about to end or that a red indication may be exhibited immediately thereafter. A circular yellow or yellow arrow indication, as appropriate, shall be displayed immediately after every circular green or green arrow interval.

Red Indication. Vehicular traffic facing a steady circular red or red arrow indication alone shall stop at a clearly marked stop line, or if none, before entering the marked crosswalk on the near side of the intersection, or if none, before entering the intersection, and shall remain stopped at the intersection until an indication to proceed is shown. (The red indication definition does not exclude right turn on red after stop, as allowed in many jurisdictions, or other such movements during the display of the red indication, as described by signs permitting such movements).

Yellow Change Interval Timing and Application Procedures

WHEN APPROACHING AN INTERSECTION, A DRIVER IS faced with one of several situations when the yellow change interval appears:

- the vehicle is traveling at a speed where the driver can stop comfortably before entering the intersection;
- the vehicle is too close to the intersection for the driver to stop comfortably and must continue at the same speed or accelerate to enter and clear the intersection before the display of a conflicting green indication;
- the driver can neither stop comfortably nor proceed into and clear the intersection before the appearance of a conflicting green indication; or
- the driver can either stop or proceed into the intersection when the yellow appears.

The third situation involving the dilemma zone is particularly prevalent when dealing with short change intervals or vehicles traveling at high speeds. The fourth situation involving the option (or decision) zone, occurs when yellow change interval lengths are long. The ideal vehicle signal change interval timing accommodates both the first and second situations while eliminating the dilemma zone and minimizing the option zone.

Determining the Yellow Change Interval Length Using Rule-of-Thumb Methods

Some designers use the approach speed in miles per hour divided by 10 to determine the length of the yellow change interval.[3] Approach speed is defined as the higher of the 85th percentile speed or the posted speed limit. Common length selections are: three seconds for speeds to 35 mph (56 kph); four seconds from 35 mph to 50 mph (56 kilometers per hour (kph) to 80 kph); and five seconds for speeds of 50 mph (80 kph) or more.[4]

Determining the Yellow Change Interval Length Using a Kinematic Model

The MUTCD[2] is the only official transportation engineering document that contains traffic control standards. The following are various formulas, among others, available to the transportation engineer for determining the yellow change interval length.

Formula 1

This formula for determining the length of the yellow change interval provides enough yellow time for a vehicle to travel, at its initial speed, over the distance it would take to stop at a comfortable average deceleration before entering the intersection:

$$y = t + \frac{v}{2a+2Gg} \qquad [1]$$

where:

y = length of the yellow change interval, to the nearest 0.1 second;
t = driver perception/reaction time, generally assumed as 1.0 second;
v = velocity of approaching vehicle, in ft/sec (m/sec);
a = average deceleration, assumed from 10 ft/sec^2 (3.0 m/sec^2) to 15 ft/sec^2 (4.5 m/sec^2);
g = acceleration due to gravity, 32 ft/sec^2 (9.81 m/sec^2); and
G = grade of approach, in percent divided by 100 (downhill is negative grade).

Formula 1 is based on the standard average deceleration kinematic model that is shown in the ITE *Transportation and Traffic Engineering Handbook*,[5] modified to include an adjustment due to the effects of grade on deceleration.[6]

Formula 2

If a red clearance interval is not used, Formula 1 may not accommodate those vehicles that choose not to stop and travel into and clear the intersection during the yellow interval. In that case, it may be desirable to extend the yellow change interval length to allow vehicles to fully clear the intersection. The *Traffic Control Devices Handbook*[7] (TCDH) suggests extending the length of the yellow change interval to allow a vehicle to clear the intersection using the following equation:

$$y = t + \frac{v}{2a+2Gg} + \frac{w+L}{v} \qquad [2]$$

where:

w = width of intersection, in ft (m);

L = length of vehicle, in ft (m) [assumed as 20 ft (6 m)]; and

v = velocity of approaching vehicle, in ft/sec (m/sec).

Variables a, G, g, T are defined above.

An intersection is defined as "... the area within the prolongation or connection of the lateral curb lines ... ," although the stop line is often used for this purpose (see also Formula 4).[1] Formula 2 provides additional yellow time to allow approaching vehicles to clear the intersection prior to the appearance of the conflicting green indications. However, it assumes that vehicles will not enter the intersection during the last portion of the yellow change interval.

Although determining the approach grade is rather straightforward, the remaining variable, v (vehicle speed), is not as well defined. Speed is generally taken to be near the 85th percentile speed, which may be above or below the posted speed limit. Some jurisdictions also consider the 15th percentile speed as well to accommodate vehicles traveling through wide intersections and/or at low speeds, as suggested by the TCDH.[7] Some agencies use the posted speed limit as the approach speed.

Use of Kinematic Formula For a Turn Lane

The use of Formula 1 may not be applicable for calculating yellow change interval lengths for protected left-turn phases because of the variety of approach speeds for turning vehicles. However, use of a more complex model can require more details than are justified. Appropriate selection of an approach speed can result in a good approximation of the timing that would have been produced by employing a more rigorous model.

Consider two possible cases. A vehicle is approaching an intersection at a through speed, which we will assume is higher than what could be safely used to execute the turn. A green left-turn arrow is being displayed. The driver begins braking to slow the vehicle to the turning speed. The signal display changes to a yellow arrow. The driver must choose whether to stop by increasing the rate of deceleration, or continue on and execute the turn, perhaps at a higher speed than initially planned.

The second case is entirely different. The driver of a vehicle stopped in a queue accelerates from a stop condition, perhaps to a speed higher than that at which the turn will be accomplished if there is some distance to the point at which the turning maneuver begins. If the signal display changes to a yellow arrow now, stopping would require going from an accelerating mode to a stopping one. Adjusting the yellow timing accordingly might decrease the possibility of the driver having to change from acceleration to deceleration mode.

In the first case, perception-reaction time is reduce considerably as the driver's foot is already on the brake pedal. In the second case, perception-reaction time is probably greater over that for nonaccelerating vehicles, and the propensity to stop may be diminished.

The through vehicle procedure may produce an adequate initial yellow change interval length if the normal perception-reaction time is used and if the vehicle speed used is the average of the through vehicle speed and the turn execution speed. Vehicles decelerating from a through vehicle speed may be traveling faster, but the perception-reaction time may provide the necessary adjustment. Similarly, the higher speed used may offset the perception-reaction time of accelerating vehicles.

Using a Uniform Value for the Yellow Change Interval Length

Some jurisdictions choose instead to establish uniform yellow change interval lengths for all intersections. This practice is predicated by research that found that, regardless of the approach speed, 85 percent of stopping vehicles stopped when they were more than three seconds away from the intersection, and 95 percent of the "going through" vehicles continued when they were less than 4.5 seconds from the intersection. The rate of deceleration of the stopping vehicles increased as the approach speed increased making the use of a constant 4.5-second yellow interval reasonable.[8,9,10]

Recent Studies on Deceleration Rates

During the early 1980s, there was increasing concern about the values assumed in the determination of the change interval length. At that time, the focus of the concern was on the value of the deceleration rate that was being used. Originally, 15 ft/sec^2 (4.5 m/sec^2) had been used. However, some jurisdictions had begun using 10 ft/sec^2 (3.0 m/sec^2). The deceleration rate value that had been used was based on very limited field data. Thus, there was interest in reevaluating the deceleration rate question.

Two rather comprehensive studies were initiated, and both included rather extensive field data collection. The first study[11,12] was conducted for the Arizona Department of Transportation, and the second study[13,14] was undertaken as part of the Federal Highway Administration (FHWA) research program. The results of both studies were somewhat similar. While the findings indicated that a deceleration rate of 10 ft/sec^2 (3.0 m/sec^2) was somewhat typical, there was considerable unexplained variation in the observed deceleration rates. Because of the results of those studies, Arizona undertook further work that specifically addressed the influence of approach grades, the impact of enforcement, and behavior associated with increases in the length of the yellow change interval.[15,16] During the course of this subsequent study, researchers[9,16] found that the variation in deceleration rates was due to the fact that drivers did not utilize a constant uniform deceleration rate. The deceleration profile selected by the driver was a function of the approach speed. For example, drivers at higher speeds selected higher initial deceleration rates, and drivers at lower speeds would select lower initial deceleration rates. Further analysis of the driver behavior found that a yellow change interval length of approximately four seconds satisfied most conditions.

Two other studies serve to validate the findings about the deceleration profiles. A study in Australia[17] examined the deceleration profiles in relation to fuel consumption. While this particular research examined stopping on highways rather than at intersections, it found that the deceleration profile did not conform to a constant and uniform deceleration rate. Another study[18] of intersections in New York concluded that a constant yellow change interval length may be a rational approximation for the design of the change interval.

Design Considerations

The recognition of the fact that drivers do not utilize a constant and uniform deceleration rate presents some rather significant issues when considering the design of the vehicle signal change interval. These issues can be summarized as:

1. The kinematic equation has been a useful tool for estimating the vehicle signal change interval. However, the limitations associated with the necessary assumptions in using the model must be recognized.
2. Attempts to refine the kinematic model by applying adjustment factors for various intersection conditions should be reconsidered in view of the more significant influence of the non-uniform deceleration profile.
3. Because of the nonuniform deceleration characteristics, it is not necessary to increase the duration of the yellow interval with increases in approach speed. The research suggests that a uniform yellow change interval length is realistic in terms of the design of the yellow change interval.

Results

Research has documented that virtually all of the above formulas for vehicle signal change interval design work acceptably, and no single method has proven superior. If one chooses to use a uniform yellow change interval, research suggests that a uniform yellow change interval length of approximately 4 seconds is adequate.

Maximum Duration of Yellow Change Interval

The MUTCD[2] indicates that the yellow change interval length should range from approximately 3 to 6 seconds. However, several entities, including ITE,[5] suggest that the yellow change interval length not exceed approximately 5 seconds. The basis of this argument is that yellow change interval lengths of long duration encourage disrespect for the traffic signal by drivers familiar with an intersection. If the calculated or selected yellow change interval length exceeds 5 seconds, it may be the choice of the local jurisdiction to handle the additional time with a red clearance interval. Furthermore, using a yellow change interval length less than 3 seconds may violate driver expectancy and result in frequent entry on red indications.

Measure of Effectiveness of Yellow Change Intervals

A primary measure of effectiveness for the yellow change interval length is the percentage of vehicles entering the intersection after the termination of the yellow indication - that is, during the red following the yellow. However, prevailing regional practices may influence driver behavior and may make comparisons difficult.

The logic behind the methodology for determining the length of the yellow change interval is that the duration of the yellow change interval should provide adequate time for a vehicle to traverse the stopping distance required by a reasonable driver. A reasonable driver closer to the intersection will proceed into and through the intersection when presented with a yellow indication. A reasonable driver further away from the intersection at the onset of the yellow indication will decide to stop and has sufficient distance to do so comfortably. Values used for the several variables in the equation are selected to determine the time to travel the stopping distance or to travel into the intersection.

When the percentage of vehicles that entered on a red indication exceeds that which is locally acceptable, the yellow change interval may be lengthened (or shortened) until the percentage conforms to local standards, or enforcement can be used instead.

Factors that May Influence Selection of Yellow Change Interval Length

Some factors may contribute to the likelihood of vehicles entering on a red indication. Thus, these factors may influence the selection or change of a yellow change interval length, uniform or otherwise. These physical conditions are:

Signal indication visibility. The displays may be too small, washed out by competing background light sources (such as the sun, street lights, low pressure sodium fixtures, billboards and commercial signs), blocked by overhanging vegetation, poorly located with respect to the driver's range of vision, or obscured by geometric alignments or other vehicles. Correction of the visibility deficiencies should be completed and evaluated before yellow change interval timing is changed.

Approach grade. Excessive downhill grades may produce very long stopping distances. Extreme grades, both uphill and downhill, in excess of 5 percent may seriously diminish the driver's desire to stop. At such locations, advisory speed plates on "Signal Ahead" sign assemblies may have some effect, and additional active measures, such as "Prepare to Stop When Flashing" sign and flashing beacon assemblies, also have been used.

Vehicle mix. It has been shown that trucks tend to maintain longer headways than other vehicles and they are proportionately more likely to be the last vehicle through the intersection or the first to stop.[19] It has also been shown that truck braking performance does not compare favorably with that of automobiles during abrupt stopping maneuvers.[20] As a result, longer yellow change interval times should be considered on approaches that have a high percentage of truck traffic. National guidelines for quantifying what constitutes a "high percentage" have not been established.

Railroad crossings. Uneven railroad crossings have the effect of decreasing speeds as drivers decelerate to avoid discomfort when crossing. Irregular vertical alignment has a similar effect, the result of which is that drivers may take longer to reach the intersection than they may have anticipated. This error can lead to drivers deciding they can reach the intersection before the onset of the red indication when, in fact, they cannot. As a result, vehicles enter on red.

Other factors. A study conducted in Georgia[21] found that as average vehicle headways on an approach decrease, drivers' tendency to enter the intersection during the yellow change interval and red clearance interval increases for a given speed. It was also found that drivers approaching from the far side of the through roadway in a "T" intersection entered longer after the onset of yellow than at other locations. There is also some indication that cycle length, as it defines the potential delay to a stopping vehicle, affects the tendency of drivers to enter during the yellow change interval. Increasing the length of the yellow change interval will not always correct the problem, as drivers may be making a conscious decision to enter when they could have stopped. Some researchers have proposed enforcement procedures to address such behavior.[22]

Red Clearance Interval Timing and Application Procedures

Use of Red Clearance Intervals

Red clearance intervals are used to allow vehicles to clear the intersection before opposing traffic receives a green indication. Policy differs from agency to agency as to whether to use a red clearance interval. It is the policy of some jurisdictions to use a red clearance interval as part of the vehicle signal change interval at all signalized intersections. The premise behind this practice is that using vehicle signal change intervals without providing adequate clearance time forces drivers approaching the intersection to be more cautious about attempting to clear the intersection.[23] However, it is also the policy of some jurisdictions to *not* use a red clearance interval at any signalized intersection.

Although most research supports the idea that the use of red clearance intervals reduces accidents at intersections, some researchers dispute this.[24] The research that disputes the use of red clearance intervals had accident rate as the primary measure of effectiveness, which was not used as a measure of effectiveness in red clearance interval studies prior to 1980. The findings indicated that implemented red clearance intervals did not significantly reduce short-term or long-term accident rates at treated intersections.[25] The City of Phoenix, Ariz., has also twice conducted large-scale studies (half of the city's signals) and found little benefit except at signals with extraordinarily high volumes (more than 100,000 vehicles per day). Some of these intersections showed reductions in the number of accidents, indicating that a red clearance interval can be effective. However, the use of red clearance intervals is sometimes an emotional public issue.

Determining the Red Clearance Interval

If a red clearance interval is used, many agencies have found success using one of the following three formulas:

$$r = \frac{w+L}{v} \qquad [3]$$

$$r = \frac{P}{v} \qquad [4]$$

$$r = \frac{P+L}{v} \qquad [5]$$

where:

r = length of the red clearance interval, to the nearest 0.1 sec;

w = width of the intersection, in ft (m), measured from the near-side stop line to the far edge of the conflicting traffic lane along the actual vehicle path;

P = width of intersection, in ft (m), measured from the near-side stop line to the far side of the farthest conflicting pedestrian crosswalk along the actual vehicle path;

L = length of vehicle, in ft (m) assumed to be 20 ft (6 m); and

v = speed of the vehicle through the intersection, in ft/sec (m/sec).

The red clearance interval duration calculated using these formulas should be treated as a maximum value. Some jurisdictions subtract up to 1.0 second from the calculated red clearance interval to recognize the fact that most drivers do not use the last portion of the yellow change interval. In addition to accident experience and signal efficiency, other considerations which may justify the use of a shorter interval include: (1) the extent to which clearing vehicles are visible to drivers of conflicting vehicles and pedestrians, and (2) the time it takes a conflicting vehicle or pedestrian to reach the point of conflict.

Although receiving limited evaluation until recently, intersection width can take a wide range of values depending on its definition and method of measurement. In this report, intersection width is defined by the actual path followed by a vehicle executing the related movement. In the case of a turning vehicle, intersection width is measured along the curved path traveled by the vehicle from the near-side stop line to the far edge of the area of conflict.

The differences among Formulas 3, 4 and 5 relate to defining the area of conflict, the intersection width, and the location of the vehicle at the end of the red clearance interval. Formula 3 is intended to place the vehicle entirely out of the area of conflict with vehicular traffic that is about to receive a green indication. Formula 4 is designed to place the vehicle at a point directly in front of pedestrians waiting to cross the far-side crosswalk. Formula 5 provides time for the clearing vehicle to be out of the area of conflict with both vehicular and pedestrian traffic. Formula 3 is generally used where there is no pedestrian traffic, and the longer of Formulas 3 or 4 where there is the probability of pedestrian crossings. Formula 5 is typically applied where there is significant pedestrian traffic or where the crosswalk is protected by pedestrian signals. Note that in application, most crosswalks are located such that the far side is closer to the intersection than the 20-ft (6-m) vehicle length used.

It may be possible with some controller units to delay the onset of the "Walk" indication relative to the start of the related green. With this operation, the "Walk" indication is delayed by an amount of time equal to the excess of the results of Formula 5 over Formula 4. The advantage of this is that vehicular traffic is less delayed, although the savings is generally very small.

As with calculating yellow change interval lengths, the selection of an appropriate value for vehicle speed is very important. The effect of vehicle speed on the length of the red clearance interval is the opposite of that on the length of the yellow change interval - as crossing speed increases, the length of the red clearance interval decreases.

To provide a reasonable red clearance time, the use of the same value for vehicle speed is not always valid. This is especially true for protected turn phases (additional details are provided elsewhere in this Informational Report). A common method for identifying the vehicle speed involves speed sampling, but estimation methods are also available.

Some researchers propose that the entire vehicle signal change interval length (yellow change plus red clearance) be calculated at both the 15th and 85th percentile approach speeds with the vehicle signal change interval's length equal to the greater of the two.[6] In the rare cases where the 15th percentile speed produces a longer interval, the red clearance interval calculated at the 85th percentile speed can be increased by the difference.[25] The original yellow change interval calculated at the 85th percentile speed is retained. The assumption is that part of the yellow change interval is used to provide the additional clearance needed by slower vehicles.

Turn maneuver speeds used for red clearance timing are those that are used in executing the turn, so the speed used is normally less than that used in calculating the yellow change interval time. The simplest way to identify the average turning speed is to make sample runs.

Measures of Effectiveness of Red Clearance Intervals

As with the yellow change interval, the test of a red clearance interval length is whether the desired result is produced. Do vehicles really clear the area of conflict, as defined by the selected equation's intent and the desired compliance percentage? If the yellow change interval length is too short, vehicles will still be in the area of conflict even if the red clearance interval length is correct. It is therefore appropriate to first evaluate the yellow change interval length.

Many of the factors that affect the yellow change interval length, particularly vehicle mix, may also impact the red clearance interval length. The presence of a large percentage of trucks may increase the speed range.

Representative Yellow Change and Red Clearance Interval Lengths

Tables 1 and 2 represent yellow change interval lengths based on Formula 1 and red clearance interval lengths based on Formula 3 presented in this report.

Table 1. Yellow Change Interval Lengths Using Formula 1 (in seconds)

85th Percentile Speed mph (km/h)	*Grade of Approach*								
	Uphill					*Downhill*			
	+4%	*+3%*	*+2%*	*+1%*	*Level*	*-1%*	*-2%*	*-3%*	*-4%*
25 (40)	2.63	2.68	2.73	2.78	2.84	2.90	2.96	3.03	3.11
35 (56)	3.28	3.35	3.42	3.49	3.57	3.56	3.75	3.85	3.95
45 (72)	3.93	4.02	4.11	4.20	4.31	4.42	4.54	4.66	4.80
55 (88)	4.58	4.69	4.80	4.92	5.04	5.18	5.32	5.47	5.64
65 (104)	5.23	5.35	5.49	5.63	5.78	5.94	6.11	6.29	6.48

A red clearance interval may be used to meet the required time shown in Table 1 when the maximum length of the yellow change interval is set at 5.0 seconds.

Table 2. Red Clearance Interval Lengths Using Formula 3 (in seconds)

85th Percentile Speed mph (km/h)	*Width of Approach feet (meters)*										
	20 (6)	*30 (9)*	*40 (12)*	*50 (15)*	*60 (18)*	*70 (21)*	*80 (24)*	*90 (27)*	*100 (30)*	*110 (33)*	*120 (36)*
25 (40)	1.09	1.36	1.63	1.90	2.18	2.45	2.72	2.99	3.27	3.54	3.81
35 (56)	0.78	0.97	1.17	1.36	1.55	1.75	1.94	2.14	2.33	2.53	2.72
45 (72)	0.60	0.76	0.91	1.06	1.21	1.35	1.51	1.66	1.81	1.97	2.12
55 (88)	0.49	0.62	0.74	0.87	0.99	1.11	1.24	1.36	1.48	1.61	1.73
65 (104)	0.42	0.52	0.63	0.73	0.84	0.94	1.05	1.15	1.26	1.36	1.47

As in all cases, engineering judgment should be utilized in the timing of vehicle signal change intervals.

Summary

THIS REPORT DOES NOT CONSTITUTE A RECOMMENDED **Practice** and is *not* intended to provide the *only* methods for determining the lengths of the yellow change intervals or the red clearance intervals. It is clear that positions and practices vary significantly regarding vehicle signal change interval timing. This report has presented a variety of methods based on differing philosophies and formulas such as uniform deceleration versus nonuniform deceleration, the kinematic model, uniform yellow change intervals, and red clearance intervals.

It was the objective of this committee to outline those methods most commonly used by traffic engineers to determine vehicle signal change interval timing. The alternatives described here provide the engineer with a degree of flexibility so that, based on local practices and philosophies, signals can be timed in the most appropriate manner to fit the needs of the community and individual intersections.

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