A. General/Purpose

Reference is made to the *WisMUTCD*, Section 4D.10.

According to State Statute 346.37(1)(b), "When shown with or following the green, traffic facing a yellow signal **shall** stop before entering the intersection unless so close to it that a stop *may not* be made in safety."

The purpose of the YELLOW vehicle clearance interval is to inform drivers of an impending change in right-of-way assignment. Yellow clearance intervals are normally 3 to 6 seconds in duration.

The purpose of the ALL-RED clearance interval is to allow vehicles to travel through an intersection that have lawfully entered during the yellow clearance interval. It *may* also provide a brief period of separation time between opposing movements. All-red clearance intervals normally do not exceed 3 seconds in duration.

B. Policy

By the *WisMUTCD*, all traffic signal installations **shall** display a yellow indication following every green interval. In addition, by this policy, state-owned signal installations **shall** operate with an all-red clearance interval for mainline and side street intersection through-vehicle movements. All-red clearance intervals *may* be used for other intersection movements, such as protected left-turns.

Fundamentally, there are three ways that yellow and all-red clearance intervals are developed: timing derived by kinematic principals, uniform timing, and rule-of-thumb,. As a statewide organization, WisDOT routinely operates signals adjacent to various jurisdictions that *may* have differing perspectives about signal timing methodology. In the interest of providing uniform conditions to the extent possible, all methods are

considered acceptable but *may* have greater applicability in certain situations or within specific areas of the state.

Kinematic Method

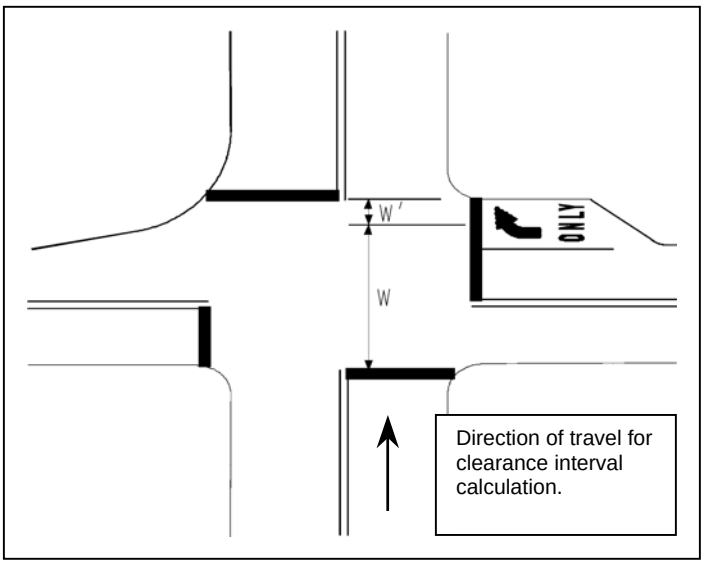
Develops a clearance interval duration based on driver behavior and physical principals. Clearance interval timing based on this method can be calculated for each intersection movement by using the following formula:

$$CT = \underbrace{prt + \frac{v}{2a + 2Gg}}_{\text{yellow portion}} + \underbrace{\frac{L + w}{v}}_{\text{all-red portion}}$$

Where:

CT	=	clearance time (*may* be rounded up to the nearest 0.5 second)
prt	=	driver perception-reaction time (usually 1.0 second)
v	=	vehicle approach speed (feet per second, vehicle approach speed *should* be based on the posted speed, or the 85-percentile speed if data is available)
a	=	average vehicle deceleration rate (usually 10 to 15 feet per second^2, 10 to 12 fps^2 recommended)
g	=	acceleration due to gravity (32 fps^2)
G	=	approach grade (expressed as decimal)
L	=	vehicle length (usually 20 feet)
w	=	intersection width (measured in feet from the near-side stop bar, see “w” diagram below)

Recommended Intersection Width ("w") Determination



Intersection width measured from approach stop bar to center of conflicting vehicle lane on the far side of the intersection. Width *may* also include distance from center of far lane to the outside edge of the traveled way ($w + w^{l}$).

When used, variables within the formula above *may* need to be adjusted for various applications & for different intersection movements. For example, in the case of left-turns, driver perception-reaction times *may* be shorter and/or vehicle approach speeds lower.

As stated above, the upper limit of the yellow and all-red clearance intervals are typically 6 and 3 seconds, respectively. Longer clearance interval times *may* breed driver non-compliance that can actually degrade intersection safety benefits. Excessively long clearance interval times will also reduce the efficiency of signal operations. The lower limit of the yellow clearance interval is typically 3 seconds.

For isolated state-owned signals that can be considered outside the influence of established timing practices of adjacent jurisdictions (for purposes of driver expectancy), it is desirable to use the kinematic method of determining vehicle clearance intervals.

For given approach speeds and gradients, the table below indicates YELLOW CLEARANCE INTERVALS calculated by the equation above (considering a <u>lower deceleration rate of 10 fps^2</u>)….

Approach Speed (mph)	Approach Grade								
	+4%	+3%	+2%	+1%	0%	-1%	-2%	-3%	-4%
25	2.6	2.7	2.7	2.8	2.8	2.9	3.0	3.0	3.1
30	3.0	3.0	3.1	3.1	3.2	3.3	3.4	3.4	3.5
35	3.3	3.3	3.4	3.5	3.6	3.7	3.7	3.8	4.0
40	3.6	3.7	3.8	3.8	3.9	4.0	4.1	4.3	4.4
45	3.9	4.0	4.1	4.2	4.3	4.4	4.5	4.7	4.8
50	4.3	4.4	4.5	4.6	4.7	4.8	4.9	5.1	5.2
55	4.6	4.7	4.8	4.9	5.0	5.2	5.3	5.5	5.6
60	4.9	5.0	5.1	5.3	5.4	5.6	5.7	5.9	6.1
65	5.2	5.4	5.5	5.6	5.8	5.9	6.1	6.3	6.5

Gray-shaded values fall outside typical time intervals indicated. Use only as needed & at the direction of the Regional Traffic Engineer.

For given approach speeds and gradients, the table below indicates YELLOW CLEARANCE INTERVALS calculated by the equation above (considering a <u>higher deceleration rate of 15 fps^2</u>)….

Approach Speed (mph)	Approach Grade								
	+4%	+3%	+2%	+1%	0%	-1%	-2%	-3%	-4%
25	2.1	2.2	2.2	2.2	2.2	2.3	2.3	2.3	2.3
30	2.4	2.4	2.4	2.4	2.5	2.5	2.5	2.6	2.6
35	2.6	2.6	2.6	2.7	2.7	2.8	2.8	2.8	2.9
40	2.8	2.8	2.9	2.9	3.0	3.0	3.0	3.1	3.1
45	3.0	3.1	3.1	3.2	3.2	3.3	3.3	3.4	3.4
50	3.3	3.3	3.3	3.4	3.5	3.5	3.6	3.6	3.7
55	3.5	3.5	3.6	3.6	3.7	3.8	3.8	3.9	3.9
60	3.7	3.8	3.8	3.9	3.9	4.0	4.1	4.1	4.2
65	3.9	4.0	4.1	4.1	4.2	4.3	4.3	4.4	4.5

Gray-shaded values fall outside typical time intervals indicated. Use only as needed & at the direction of the Regional Traffic Engineer.

For given intersection widths and approach speeds, ALL-RED CLEARANCE INTERVALS calculated by the equation above are….

Approach Speed (mph)	Intersection Width (ft)								
	24	36	48	60	72	84	96	108	120
25	1.2	1.5	1.9	2.2	2.5	2.8	3.2	3.5	3.8
30	1.0	1.3	1.5	1.8	2.1	2.4	2.6	2.9	3.2
35	0.9	1.1	1.3	1.6	1.8	2.0	2.3	2.5	2.7
40	0.7	1.0	1.2	1.4	1.6	1.8	2.0	2.2	2.4
45	0.7	0.8	1.0	1.2	1.4	1.6	1.8	1.9	2.1
50	0.6	0.8	0.9	1.1	1.3	1.4	1.6	1.7	1.9
55	0.5	0.7	0.8	1.0	1.1	1.3	1.4	1.6	1.7
60	0.5	0.6	0.8	0.9	1.0	1.2	1.3	1.5	1.6
65	0.5	0.6	0.7	0.8	1.0	1.1	1.2	1.3	1.5

Gray-shaded values fall outside typical time intervals indicated. Use only as needed & at the direction of the Regional Traffic Engineer.

Uniform Timing

Assigns a standardized duration for the clearance interval regardless of location. In this case, times *may* be based on the type of movement being made. For example, based on higher vehicle speeds, a through movement on a mainline approach *may* have a longer yellow clearance time then for a side street through movement or for a protected left-turn.

This method *may* be used when a state-owned signal is located in close proximity to signals operated in this manner by another jurisdiction. The purpose being, to address driver expectancy issues. However, assigning a single clearance interval value for all intersections and intersection movements is not recommended.

Rule-of-Thumb

Assigns a standardized duration for the clearance interval based on vehicle approach speed, the type of movement being made, or roadway classification. For example, mainline and sidestreet through movements *may* have the following yellow clearance interval durations:

- Approach speed <30 mph = 3 seconds
- Approach speed between 30 & 50 mph = 4 seconds
- Approach speed >50 mph = 5 seconds
- Protected left-turns = 3 seconds

The interval times indicated are for demonstrative purpose only. Similarly though, all-red clearance times *may* be categorized.

This method *should* typically be used when a state-owned signal is located in close proximity to signals operated by another jurisdiction using this method to address driver expectancy issues.

C. Support

Even nationally, there is no clear consensus on appropriate methodology for determining vehicle clearance times[1]. According to ITE, "Divergent and strongly held positions are common when vehicle signal change interval lengths are discussed. Some believe that a common interval length is best, while others believe that uniform yellow change interval lengths are wrong….". This finding was verified more recently in an ITE document titled, Signal Timing Practices and Procedures – State of Practice dated March 2004.

The kinematic methodology is the typically the most desirable unless driver expectancy would be better served through the use of the other principals described above.

As stated above, since WisDOT signals routinely operate near locally owned installations, the intent *should* be uniformity across an appropriate area or along a specific corridor. As such, proper coordination with other jurisdictions *should* take place. If a crash or red light running problem exists, vehicle clearance intervals *should* be verified and, if needed, reasonably extended.

Determining Vehicle Signal Change and Clearance Intervals, ITE, August 1994