FLASHING ADVANCE WARNING LIGHTS

Background

These devices go by several names but in general refer to a sign that has flashing lights on it that come on when the signal ahead is going to turn from green to yellow and then stay flashing until the green comes on again. The messages on the sign vary, with “Prepare to Stop When Flashing” a common one. The device is often employed as a countermeasure to several problems, all of which are somewhat interrelated. It may be used as a method of providing dilemma zone protection, especially at high-speed approaches. It can also be used to alert motorists to a signalized intersection that has limited sight distance, has heavy truck traffic, is located on a downgrade, is at an unexpected location, or a combination of these. Finally, it can be used as a countermeasure to reduce red-light running. There have been several studies that address the effectiveness of these devices and at least two state DOTs have guidelines for their deployment. Following are excerpts from three of the documents that summarize the results of these studies and reflect the key findings of the literature. The guidelines found in the literature review are given after these three excerpts.

Excerpt No. 1 (see references at end of this section)
Source: Dilemma Zone Protection with Advance Detection and Active Warning Signs. Patrick T. McCoy and Geza Pesti

Active (Flashing) Advance Warning Signs for Dilemma Zone Protection

Common methods of providing dilemma zone protection on high-speed approaches are advance detection and active advance warning signs. In the case of advance detection, a series of detectors are placed on the intersection approach so that approaching vehicles are able to extend the green as they travel through the dilemma zone and prevent the onset of yellow while they are in the dilemma zone. Studies in Kentucky (3), Texas (4), and California (5) have found that advance detection is effective in reducing crashes and traffic conflicts on high-speed approaches to signalized intersections. However, some (1,2) have noted the long allowable gaps provided by advance detection designs increase the frequency of reaching the maximum green interval at which point the green is terminated and the yellow is displayed immediately without regard to the presence of vehicles in the dilemma zone. The termination of green in this manner is referred to as “max-out.” Thus, when max-out occurs, the dilemma zone protection is lost. This becomes a greater problem as traffic volumes on the approach increase.

Active advance warning signs consist of warning signs equipped with one or more yellow flashing beacons. The signs typically used are warning signs with the legend PREPARE TO STOP WHEN FLASHING or the symbolic SIGNAL AHEAD warning sign. The signs are interconnected with the traffic signals at the intersections so that the flashers are activated at a predetermined time before the end of the green interval. This time is based on the distance from the sign to the stop line and the prevailing approach speed, or the posted speed limit. In this way, the signs are intended to reduce the indecision of drivers and the variability in their behavior by providing them with additional information about the status of the traffic signal ahead. A
synthesis of practice (6) related to accident countermeasures at high-speed signalized intersections concluded that active advance warning signs are generally believed to be most effective at intersections hidden from the view of approaching traffic and on expressways where traffic signals are least expected. An evaluation of the accident experience at isolated high-speed signalized intersections in California (5), indicated that active advance warning signs on high-speed signalized intersection approaches are effective in reducing total, rear end, right-angle, and nighttime accidents. However, the results of a before-and-after study of accidents at high-speed signalized intersections in Minnesota (7) were mixed. Some intersections experienced reductions in total, right angle, and rear end accident rates after the installation of active advance warning signs and others did not. Inconsistent results were also found by a study of high-speed signalized intersections in British Columbia, Canada (8). An average reduction of 25 percent was found, but the accident reduction among the 25 study sites ranged from -44 to +65 percent. In comparing the 25 sites with active advance warning signs to 81 high-speed signalized intersections without active advance warning signs, it was concluded that active advance warning signs were effective in reducing the frequency and severity of accidents when the major and minor road ADTs were above 15,000 and 3,000, respectively.

Traffic conflict studies (7) of active advance warning signs conducted in Minnesota found the lowest rates of red-light running violations at locations with active advance warning signs. Similarly, an Ohio study (9) also found fewer red-light running conflicts on high-speed approaches to signalized intersections with active advance warning signs. In addition, these studies revealed that drivers accelerated at the onset of yellow, but drivers decelerated at the beginning of the dilemma zone when the beacons were flashing and the signal indication was green.

Nebraska Experience

Conventional advance detection designs have not been effective at some intersections on the state highway system in Nebraska. Therefore, the NDOR developed a new design that includes the activation of flashing beacons on advance warning signs before the onset of yellow, advising drivers to be prepared to stop. Comments about the new design received by the NDOR from drivers, especially truck drivers, have been very favorable. However, there is some anecdotal evidence that suggests that the novelty effects of the design may have accounted for its initial success and its effectiveness may diminish over time. In addition, the results of studies conducted by other states (7,9) and the Federal Highway Administration (10) recommend against such use of active advance warning signs, because they were found to encourage drivers to accelerate at the onset of yellow in an attempt to enter the intersection before the onset of red. In 1999, there were five signalized intersections where the NDOR had replaced the conventional design with the new design. In light of the anecdotal evidence and previous research, it was not clear whether or not the conventional designs at other intersections should also be replaced. If the new design does not improve dilemma zone protection, a decision to replace the existing systems would be counterproductive, waste highway funds, and possibly increase the NDOR’s exposure to tort liability claims. On the other hand, if the new design does improve dilemma zone protection, a decision not to replace the existing systems would not be in the best interests of highway safety.
References for Excerpt No. 1


Excerpt No. 2 (see references at end of this section)

Source: Advance Warning Flashers: Do They Improve Safety? Tarek Sayed, Homayoun, and Felipe Ridriguez.

Background

In North America, AWFs constitute a number of different warning devices, varying in terms of shape, number of flashers, text and symbols. In general however, they can be categorized into the following three types:

- **Prepare to Stop When Flashing (PTSWF)**
  The PTSWF sign is essentially a warning sign with the text "PREPARE TO STOP WHEN FLASHING" and complemented by two amber flashers which begin to flash a few seconds before the onset of the yellow interval (at a downstream signalized intersection) and continue to flash until the end of the red interval.

- **Flashing Symbolic Signal Ahead (FSSA)**
  This device is similar to the PTSWF sign except that the words "PREPARE TO STOP WHEN FLASHING" are replaced by a schematic traffic signal comprised of a rectangle with solid red, yellow and green circles. The flashers operate in the same manner as the PTSWF sign.

- **Continuous Flashing Symbolic Signal Ahead (CFSSA)**
  As the name suggests, this device is identical to the FSSA sign but has flashers that flash all the time - with the flashers not being connected to a traffic signal controller.

The key considerations for an AWF installation are location and timing of the sign. Here, location refers to the distance, upstream of a signalized intersection, at which the AWF is located. This distance must be equal or greater than that required to perceive and react to the flasher, and stop the vehicle safely. Timing, on the other hand, refers to the length of time prior to the yellow interval of the downstream signalized intersection, at which the AWF commences flashing. In this regard, timing is a function of the more critical sign location. A recurring finding within the literature is that engineering judgment is often the principal guide for AWF installation. However, some jurisdictions have actual published policies for the arrangement and installation of AWFs, with key warranting criteria being accident history, isolated intersections, and sight distance restrictions (1).

Current Practice in British Columbia

In British Columbia, provincial AWFs are rectangular in shape and are equipped with two 200-millimeter yellow signal head sections located in each of the upper corners. These signals operate in an alternate flashing mode, at a rate of 60 flashes per minute, and with the "on" period equal to the "off" period. Furthermore, AWF signs are illuminated and mounted overhead on standard Ministry sign poles positioned over the shoulder. According to the Ministry of Transportation and Highways guidelines (2), AWFs are recommended at provincial intersections where one of the following conditions are satisfied:
the posted speed limit on the roadway is 70 kilometer per hour or greater;
- the view of the traffic signals is obstructed due to vertical and/or horizontal alignment (irrespective of the speed limit) such that a safe stopping distance is not available;
- there is a grade, in the approach of the intersection, requiring more than the normal braking effort; or,
- where drivers are exposed to many kilometers of high speed driving (regardless of posted speed limit), and encounter the first traffic signal in a developed community.

Previous Work

The majority of the literature reviewed was found to base AWF evaluations on the following measures:

- a reduction in approach speeds;
- a reduction in the number of certain types of traffic conflicts; and
- a reduction in accident frequency.

The focus of these evaluations was found to be the speed profile of vehicles approaching an AWF during the changing phases of a downstream traffic signal and the frequency of red light violations before and after the AWF installation. The emphasis on accident frequency between AWF and non-AWF sites was found to be minimal.

Approach Speeds

In a comparative evaluation of PTSWF and FSSA signs against CFSSA signs in Ohio, Pant and Xie (3) concur that the impacts of the various AWF signs varied among intersections with tangent and curved approaches. In analyzing approach speed profiles, Pant and Xie note that vehicles accelerated at the beginning of the dilemma zone when the AWFs were inactive and the signal indication was green but decelerated at the beginning of the dilemma zone when the AWFs were active. However, in placing emphasis on the former, they discourage the use of PTSWF or FSSA signs at high speed signalized intersections with tangent approaches, while also recommending that in general, CFSSA signs should be considered prior to the implementation of PTSWF or FSSA signs.

In a study on the use and operation of AWFs in Minnesota, Klugman, et. al. (1) reconfirm that speeds are higher when the AWF is not flashing, and lower when it is flashing during a green signal indication. In general, while the approach speed evaluations do show an undesired effect of vehicles accelerating when the AWF is off, these effects must be compared against the benefits of other effects such as decelerating when the AWF is on. Such benefits need to be correlated with other evaluation measures such as traffic conflicts or accident rates.

Traffic Conflicts

The number and severity of certain type of traffic conflicts, such as red light violations or abrupt stoppages, represent another measure for evaluating AWFs. Most of the literature reviewed did include as part of its speed data collection, some form of traffic conflict evaluation.
In this regard, when comparing PTSWF and FSSA signs with CFSSA signs, Pant and Xie correlated CFSSA signs with twice as many red light violations as with the other AWFs, while correlating a higher percentage of abrupt stoppages with the PTSWF signs (3). Similarly, in Minnesota, Klugman, et. al. found that the highest percentage of red light violations occurred at sites without any form of AWF device, with substantially lower percentages of violations at sites with AWFs (1).

**Accidents Frequency**

In an evaluation of high speed isolated signalized intersections in California, Gibby, et. al. (4) correlated various operational and physical intersection features such as signal timing and phasing, medians, channelization, and AWFs with safety and accident frequency. Using a sample of 40 intersections, and 10 years of accident data which covered periods before and after the change in characteristics considered, they found that high speed approaches with AWFs had significantly lower total, right-angle, and rear-end approach accident rates, and ratios of night time accidents, than those without AWFs.

Klugman et. al. also included an analysis of accidents as part of their evaluation of AWF implementations (1) – with the focus being AWF impacts on the frequency of specific accident types. They used a sample of 14 intersections from two different districts, and six years of accident data covering a three-year period preceding and following the installation of the AWF units. Using a simple before and after comparison of intersection accident rates, they found that the total, right angle and rear-end accident rates at AWF equipped sites decreased in one district and increased in another.

**References for Excerpt No. 2**

Advanced Warning Flashers - Purpose and Installation Guidelines

Advanced warning flashers operate as an integral part of the signal system and are intended to provide advance warning to the approaching motorist on the trunk highway that the signal system will be turning yellow during their approach. Truck drivers find advance warning flashers to be particularly beneficial due to the mass and momentum of their vehicles.

As described in the Minnesota Manual on Uniform Traffic Control Devices 2C-17.2, the advance warning flashers are pedestal mounted signs (BE PREPARED TO STOP and WHEN FLASHING) with accompanying dual eight inch yellow beacons which flash in a wig-wag manner (interior/exterior flash) prior to the termination of the green (this time period is defined as the leading flash), and during the yellow and red periods of the signal. Two pedestals, each with two flashing beacons, are installed flanking the trunk highway on divided highways. The distance from the stop bar to the advanced warning flasher is determined by the speed limit of the approach.

The advanced warning flashers also flash if the entire signal system goes into flash operation. Power to the advanced warning flashers is supplied from the signal control cabinet as a fail safe. Advanced warning flashers must be installed in both directions of the high-speed approach in order to maintain dilemma zone protection within the controller programming.

Figure 3
Advanced Warning Flashers Flanking Trunk Highway
Guidelines, established by Mn/DOT in Technical Memorandum 97-04-T-02, provide a framework to analyze individual signalized intersections for advanced warning flasher installation. Generally, advanced warning flashers are not installed with new signal systems but are considered for in place signal systems in response to specific problems and address a combination of the guidelines identified below:

- Speed - 85th percentile speed greater or equal to 50 mph
- Isolated or unexpected signalized intersection
- Limited sight distance - based on gradient, 85th percentile speed, reaction time, deceleration rate
- Dilemma zone - yellow interval not lengthy enough based on 85th percentile speed, reaction time, deceleration rate, gradient
- Accidents
- Engineering judgment

The technical memorandum also identifies the appropriate leading flash, in seconds, based upon the posted speed of the approach and the location of the advanced warning flasher. For example, a speed limit of 55 mph requires placement at 700 feet from the stop bar with a leading flash of seven seconds while a speed limit of 60 mph requires placement at 850 feet from the stop bar and a leading flash of eight seconds.

Advanced warning flashers are not necessary for safe and efficient operation of traffic signal systems. They should not be considered a standard signal system component for the following reasons:

- The leading flash creates a delay for the overall operation of the signal system,
- There exists an ongoing concern that a proportion of drivers use the flashers to “overdrive” the signal timing and “race” the signal system - thereby becoming a hazard,
- Resources for construction, power and maintenance would limit other work,
- The “punch” that the flashers provide would be diminished if used excessively, and
- Such a supplementary system is not perceived by drivers to be needed at an overwhelming majority of signal systems.
GUIDELINE 1
Current Practice in British Columbia

In British Columbia, provincial AWFs are rectangular in shape and are equipped with two 200-millimeter yellow signal head sections located in each of the upper corners. These signals operate in an alternate flashing mode, at a rate of 60 flashes per minute, and with the "on" period equal to the "off" period. Furthermore, AWF signs are illuminated and mounted overhead on standard Ministry sign poles positioned over the shoulder. According to the Ministry of Transportation and Highways guidelines, AWFs are recommended at provincial intersections where one of the following conditions are satisfied:

- the posted speed limit on the roadway is 70 kilometer per hour or greater;
- the view of the traffic signals is obstructed due to vertical and/or horizontal alignment (irrespective of the speed limit) such that a safe stopping distance is not available;
- there is a grade, in the approach of the intersection, requiring more than the normal braking effort; or,
- where drivers are exposed to many kilometers of high speed driving (regardless of posted speed limit), and encounter the first traffic signal in a developed community.
$407\text{-}2$ PREPARE TO STOP WHEN FLASHING Signs (W3-H6)

$407\text{-}2.1$ General

The PREPARE TO STOP WHEN FLASHING (PTSWF) sign (W3-H6) is used to provide drivers approaching a traffic signal with additional information concerning the changing of the traffic signal indication from green to yellow. Drivers who are past the dilemma zone will usually decide to continue through the intersection when the yellow indication is displayed, while drivers who have not yet entered the dilemma zone will decide to stop. This sign can also be used to provide advance information when the geometric design of the intersection approach prevents the signal display from being seen in time to stop.

$407\text{-}2.2$ Applications

The following are typical applications for PTSWF signs. Installation of the PTSWF sign should only be implemented upon failure of the progressive application of countermeasures just described:

1. A location (usually four-lane divided) with high approach speeds (> 45 miles per hour), a high rear-end accident rate, and evidence of rear-end conflicts (skid marks) at the intersection.

2. A remote rural location with high speeds where the presence of a signal is unexpected.

3. A location with high approach speeds and diminished signal sight distance due to horizontal and/or vertical curves or structures.

4. A location with a high percentage of high-speed truck traffic with frequent violations of the clearance interval and excessive angle and rear-end accidents. The installation of a signal can be expected to significantly increase rear-end accidents even at locations without the above described characteristics. No signalized intersection is likely to be completely free of rear-end accidents. Consequently, restraint should be exercised in the use of PTSWF signs since the overuse of any warning device can reduce its effectiveness. It should also be noted that the use of this device reduces the efficiency of the signal operation by delaying the termination of the green. Also, studies of PTSWF applications have shown that vehicle speeds through the intersection may increase.

$407\text{-}2.3$ Procedure

Prior to installation of the PTSWF signs, it should be determined that proper advance signing has been in place and that the detectors are operating correctly and are located beyond the dilemma zone for the approach speeds involved. If the detectors and Signal Ahead (W3-3) signs are improperly located, this should be corrected and evaluated before installing PTSWF signs. Other detector design techniques to minimize dilemma zone exposure may also be employed. Generally, the PTSWF sign should be used only where conventional traffic control devices have been tried and found ineffective in reducing accidents, or where operational problems related to rear-end, or other accidents caused by failure to stop, have occurred. For existing signalized intersections, the following progressive application of countermeasures should be utilized to address accidents caused by failure to stop:
1. Installation of a single Signal Ahead (W3-3) sign.

2. Dual W3-3 signs.

3. Oversized, dual W3-3 signs.

4. W3-3 signs with continuously flashing beacons.

5. Extended Call - Delay Call Loops (EC-DC Loops).

6. PTSWF (W3-H6) signs.

407-2.4 Operations and Placement

The PTSWF sign installation typically consists of the following equipment:

- PTSWF sign,
- Flashing beacons with down lights,
- Sign bracket assembly,
- Sign support with breakaway foundation,
- Flasher and flash control assembly, and
- Wiring to connect flashing beacons and controller.

Auxiliary equipment shall be provided in the signal controller to operate the PTSWF sign beacons. This equipment shall be set to start the sign beacons flashing for a predetermined number of seconds (with variable settings) before the termination of green. Flashing operation of the PTSWF sign shall typically end when green is displayed to the approach. The beacons shall flash simultaneously. The beacons shall not be activated when the signal controller operation goes to “flash” mode. For high-speed applications at four-legged intersections, PTSWF signs shall be employed for both directions of a roadway unless there are factors which would dictate the need for one direction only. When PTSWF signs are used on four-lane divided highways, dual installation should be considered.

When a PTSWF sign is added to an approach with W3-3 signs with beacons already in place, the beacons on the W3-3 signs shall be removed.

The symbolic Signal Ahead (W3-3) sign shall be used in conjunction with a PTSWF sign and governed by the following provisions:

- The W3-3 sign shall always be located in advance of the PTSWF sign.
- It shall be no closer than 200 feet (60.96 meters) to the PTSWF sign, and must also meet the minimum placement criteria described in OMUTCD Section 2C.26.
- If the PTSWF sign is installed subsequent to the W3-3 sign (which is usually the case), the W3-3 sign may require relocation to comply with the 200 foot (60.96 meters) sign spacing criteria.
The following factors are needed to determine PTSWF sign location (S) and timing (T):

- **t**: perception-reaction time in seconds
- **1.47**: conversion factor from miles per hour to feet per second, (0.278 for km/hr to m/s)
- **V₁**: 85th percentile approach speed, mph (km/hr)
- **V₂**: 15th percentile approach speed, mph (km/hr)
- **f**: .266 coefficient of friction (wet)
- **g**: approach grade, percent/100
- **S**: sign location from stop line, ft.(m)
- **T**: delay timing, sec.

- **a**: 100 feet (30.48 m), represent a zone in front of sign where drivers would be unable to perceive meaning of flashing sign
- **b**: distance \[1.47(t)(V₂)\] \[0.278(t)(V₂)\] (metric units), space in front of the dilemma zone where most drivers would not attempt to stop.

S & T are calculated by:

\[
S = 1.47V₁t + \frac{V₁²}{30(f+g)} \\
S = 0.278V₁t + \frac{V₁²}{254.92(f+g)} \quad \text{(metric units)}
\]

\[
T = \frac{S + a\cdot b}{1.47V₂} \\
T = \frac{S + a\cdot b}{0.278V₂} \quad \text{(metric units)}
\]

**Example in English Units**: \(V₁ = 58\) mph, \(V₂ = 47\) mph \(g = + 0.5\%\)

\[
S = (1.47)(58)(1.0) + \frac{58²}{30(0.266+.005)} \\
T = \frac{496+100-(1.47)(1.0)(47)}{1.47(47)}
\]

\[
S = 25.9 + 126.2 \\
S = 259 \text{ Ft.}
\]

\[
T = 7.7 \text{ sec.}
\]

**Example in Metric Units**: \(V₁ = 93.34\) km/hr (58 mph), \(V₂ = 75.64\) km/hr (47 mph), \(g = + 0.5\%\)

\[
S = (0.278)(93.32)(1.0) + \frac{93.32²}{254.92(0.266+0.005)} \\
T = \frac{152.1+30.48-(0.278)(1.0)(75.64)}{0.278(75.64)}
\]

\[
S = 25.9 + 126.2 \\
S = 152.1 \text{ Meter}
\]

\[
T = 7.7 \text{ sec.}
\]
407-2.5 Criteria for Removal

The following should be used as criteria for removal:

1. When there are two or more signalized intersections on the same route and the spacing between each signal is 0.5 mile (800 meters) or less.

2. When a signal becomes part of a coordinated system.

3. When the posted speed is reduced to less than 45 miles per hour (72 km/hr).

4. Upon mitigation of the condition that caused the sight distance limitation where the PTSWF sign is installed.

Prior to removal of the PTSWF signs, the signs shall be covered and flashers disconnected for a minimum of ten days.
GUIDELINE 3

9-4.02.03 Advance Warning Flashers Consideration

An Advance Warning Flasher (AWF) is a device that Mn/DOT uses to convey to the motorist information about the operation of a traffic signal. An AWF is typically found at certain high-speed locations where it may be necessary to get the motorists attention through a visual indication about a pending change in the indication of a traffic signal. The AWF assists the motorists in making safer and more efficient driving decisions by informing them that they must prepare to stop. The AWF configuration, placement, and timing details can be found the Chapter 4M of the MN MUTCD.

The following guidelines indicate when the installation of advance warning flashers (AWF) for signal change interval should be considered. Due to the complex nature of traffic flow characteristics, these guidelines should be applied along with engineering judgment. Guidelines should be reviewed for each prospective installation.

An AWF should only be installed in response to a specifically correctable problem, not in anticipation of a future problem. Generally, AWF implementation is appropriate only at high-speed locations. Before an AWF is installed, other remedial action should be considered.

The following guidelines generally apply only where posted speed is 55 mph or higher:

1. An isolated or an unexpected signalized intersection
   This situation can occur where there is a long distance from the last intersection at which the mainline is controlled, or the intersection is otherwise unexpected. This guideline may be applicable where the distance from the last intersection is greater than 15 km (10 miles), a freeway terminus, or at other locations where the intersection is unexpected.

2. A Limited sight distance
   This can occur where the distance to the stop bar, D, with two signal heads visible is insufficient. See Graphs of Limited Sight Distance, Table 9.1A & Table 9-1B. A sight distance falling below the lines for the given speed and grade indicates the possible need for an AWF.

\[
D \leq 0.45vt + \frac{v^2}{10(a + 9.8a)} \quad \text{(metric)}
\]

\[
D \leq 1.497vt + \frac{v^2}{0.93(a + 32.2a)} \quad \text{(English)}
\]

Where:
- \(D\) = distance to stop bar in meters or feet
- \(v\) = posted speed limit in mph
- \(t\) = reaction time, 2.5 seconds
- \(a\) = deceleration rate
  - for trucks use 2.4 m/s^2 (metric)
  - 8 ft/s^2 (English)
  - for all traffic use 3.0 m/s^2 (metric)
  - 10 ft/s^2 (English)
- \(s\) = positive or negative decimal gradient

3. Dilemma zone
   This situation exists when a dilemma zone exists for all traffic or for heavy vehicles. A dilemma zone exists if the yellow interval time cannot practically be set to at least the yellow interval time indicated in Signal Timing Manual. An AWF may be considered but longer yellow should be considered first.
4. Crashes
   If an approach has a crash problem, the intersection should be examined for existence of dilemma zone or sight distance restriction. If no sight distance or dilemma zone problems exist, an AWF may not be an appropriate countermeasure for accident problems.

5. Heavy Truck Volume
   Where the roadway has a grade of 3% or greater and truck volume exceeds 15%.

6. Engineering Judgment
   Combinations of the above guidelines or other considerations may justify the installation of an AWF.

   Engineering judgment should be based on additional data such as complaints, violations, conformity of practice, and traffic conflicts. Prior to installing an AWF, consideration should be given to other countermeasures including but not limited to: adjustment of timing parameters which may include increasing yellow and/or all red intervals, improving detection, modification of the signal system as by adding signal heads, adjusting speed limits, and installing continuously operating flashers with standard "signal ahead" warning signs.
Limited Sight Distance

\[ a = 3.0 \text{ meters (10 feet) per second squared} \leq 15\% \text{ trucks} \]

<table>
<thead>
<tr>
<th>Posted Speed, mph</th>
</tr>
</thead>
<tbody>
<tr>
<td>45 (330)</td>
</tr>
<tr>
<td>50</td>
</tr>
<tr>
<td>55</td>
</tr>
<tr>
<td>60</td>
</tr>
<tr>
<td>65</td>
</tr>
<tr>
<td>70</td>
</tr>
</tbody>
</table>

Sight Distance to Stop Bar, meters (feet)

- 3\% Grade
- +3\% Grade
- Level

A sight distance falling below the lines for the given speed and grade indicates the possible need for an AWF.
GUIDELINE 4
Excerpt from the Minnesota MUTCD, December 2001

PART 4. HIGHWAY TRAFFIC SIGNALS
Chapter 4M. Advance Warning Flashers

4M.1 Description

SUPPORT:

The Advanced Warning Flasher (AWF) is a device that, at certain high-speed locations, has been found to provide additional information to the motorist describing the operation of the traffic signal. It has been found that and Advance Warning Flasher can assist the driver in making safer and more efficient driving decisions. The additional information includes a visual indication to get the driver's attention and a specific notice that the driver must prepare to stop.

The Minnesota Advance Warning Flasher system consists of a flasher and a sign located on main street approaches to a high-speed signalized intersection. The AWF is connected to the traffic signal in such a way that when the main street green is about to change to yellow, the flasher is turned on to warn the approaching drivers of the impending change. Basically, the purpose of an optimally designed combination of traffic signal and Advance Warning Flasher system is twofold: 1) to inform the driver in advance of a required drive decision (prepare to stop) and 2) to minimize the number of drivers that will be required to make that decision.

4M.2 General Design and Operation

GUIDANCE:

If used, then the guidelines for installation should be the following:

1. Advance Warning Flasher - The Advanced Warning Flasher assembly is shown in Figure 4M-1. The flasher shall flash yellow in a wig-wag manner prior to the termination of the green (See number 3 below), and during the yellow and red periods of the signal. The flasher will also flash if the signal goes into flashing operation. Power shall be supplied to the Advance Warning Flasher from the signal control cabinet.

<table>
<thead>
<tr>
<th>Posted Speeds (mph)</th>
<th>AWF Placement (feet)</th>
<th>Leading Flash (seconds)</th>
</tr>
</thead>
<tbody>
<tr>
<td>40</td>
<td>170</td>
<td>8.0</td>
</tr>
<tr>
<td>45</td>
<td>170</td>
<td>7.0</td>
</tr>
<tr>
<td>50</td>
<td>215</td>
<td>7.0</td>
</tr>
<tr>
<td>55</td>
<td>215</td>
<td>7.0</td>
</tr>
<tr>
<td>60</td>
<td>260</td>
<td>8.0</td>
</tr>
<tr>
<td>65</td>
<td>260</td>
<td>7.5</td>
</tr>
</tbody>
</table>

Table 4M-1. Advance Warning Sign Placement

2. Advance Warning Flasher Sign Placement – The Advance Warning Flasher should be set back from the intersection in accordance with the Table 4M-1. Where this is not possible, the leading flash must be adjusted for the actual distance by using the formula below. At locations on four-lane divided roadway, it shall be placed on both sides of the approach.
3. Leading Flash - The Leading Flash is the amount of time, prior to the signal turning yellow that the Advance Warning Flasher flashes. It shall flash during the Leading Flash Period and continue flashing through the signal’s yellow clearance interval and the red. The Leading Flash time is shown in Table 4M-1.

For existing systems where the placement is other than what is listed in Table 4M-1, the Leading Flash Time can be computed by the following formula:

\[
\text{Metric: } F = \frac{2.24D}{v} - 1.5 \\
\text{English: } F = \frac{0.68D}{v} - 1.5
\]

Where:
- \( F \) = Leading Flash Time (seconds)
- \( D \) = AWF Placement (meters or feet)
- \( v \) = Posted Speeds (mph)

4. Detector Placement - The detection of the intersection shall be determined without regard to the Advance Warning Flasher.
GUIDELINE 5
Training Information from the Minnesota DOT, January 2004

TOPIC 10: ADVANCED WARNING FLASHER

Traffic Signals 101

Topic 10
Advanced Warning

In this chapter you will be introduced to Advanced Warning Flashers (AWF).
The information presented in this section is from the MUTCD Section 4M and the TEM Chapter 9. A copy of the relevant sections from these documents is included at the end of this topic.

Advanced Warning

Advanced Warning Flasher (AWF)

PREPARE TO STOP WHEN FLASHING

January 2004 Traffic Signal 101
Advanced Warning

Advanced Warning Flasher

Front and rear view of AWF.
Advanced Warning

Advanced Warning Flasher
- The Advanced Warning Flasher (AWF) is a device which, at certain high speed locations, has been found to provide additional information to the motorist describing the operation of the traffic signal
- Advance Warning Flasher can assist the driver in making safer and more efficient driving decisions

The Minnesota AWF system consists of a flasher and a sign located on main street approaches to a high speed signalized intersection. It is connected to the traffic signal in such a way that when the main street green is about to change to yellow, the flasher is turned on to warn the approaching drivers of the impending change. Basically, the purpose of an optimally designed combination of traffic signal and AWF system is twofold: 1) to inform the driver in advance of a required drive decision (prepare to stop) and 2) to minimize the number of drivers that will be required to make that decision.

Pictures of the Advanced Warning Flasher (AWF) are shown on slides 2, 3 and 4.
Advanced Warning

The guidelines in Chapter 9 of the Traffic Engineering Manual indicate when the installation of advanced warning flashers (AWF) for signal change interval should be considered. Due to the complex nature of traffic flow characteristics, these guidelines should be applied along with engineering judgement. Guidelines should be reviewed for each prospective installation.

Advanced Warning

- Advanced Warning Flasher Consideration (TEM Chap 9)
  - Isolated or unexpected signalized intersection
  - Limited sight distance
  - Dilemma Zone
  - Crashes
  - Heavy Truck Volume
  - Engineering Judgment

The AWF shall flash yellow in a wig-wag fashion manner prior to the termination of the green, and during yellow and red periods of the signal.

The flasher shall be set back from the intersection as shown on the next slide.

The leading flash is the amount of time, prior to the signal turning yellow, that the AWF flashes.

The detection of the intersection shall be determined without regard to the AWF.

- Guidelines for Installation (MUTCD 4M.2)
  - Advanced Warning Flasher
  - Advanced Warning Flasher Sign Placement
  - Leading Flash
  - Detector Placement
## Advanced Warning

The AWF set back location based on the posted speed (mph). This table can be found in the MN MUTCD.

<table>
<thead>
<tr>
<th>Posted Speeds (mph)</th>
<th>AWF Placement</th>
<th>Leading Flash (seconds)</th>
</tr>
</thead>
<tbody>
<tr>
<td>40</td>
<td>170</td>
<td>560</td>
</tr>
<tr>
<td>45</td>
<td>170</td>
<td>560</td>
</tr>
<tr>
<td>50</td>
<td>215</td>
<td>700</td>
</tr>
<tr>
<td>55</td>
<td>215</td>
<td>700</td>
</tr>
<tr>
<td>60</td>
<td>260</td>
<td>850</td>
</tr>
<tr>
<td>65</td>
<td>260</td>
<td>850</td>
</tr>
</tbody>
</table>

The figure to the left is an Advanced Warning Flasher Detail. A copy of the most current version of this can be downloaded from the website.