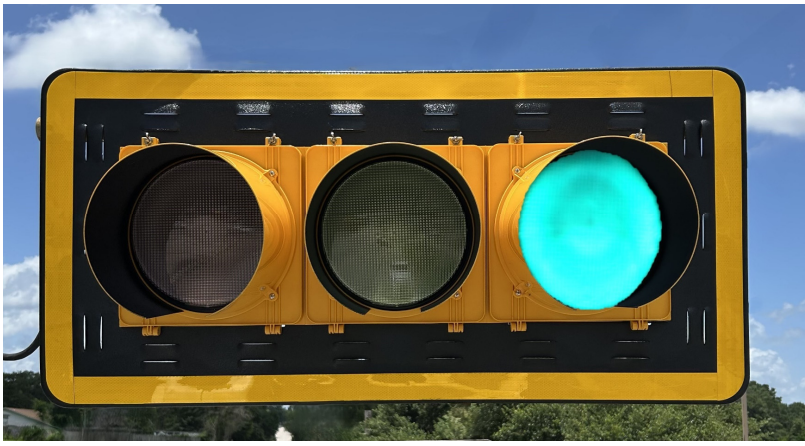
Part 4 Highway Traffic Signals













Texas MUTCD

Texas Manual on Uniform Traffic Control Devices

PART 4
HIGHWAY TRAFFIC SIGNALS

CHAPTER 4A. GENERAL

Section 4A.01 Types

Support:

01 The following types and uses of highway traffic signals are discussed in Part 4: traffic control signals; bicycle signal faces; pedestrian signal heads; hybrid beacons; rectangular rapid flashing beacons; emergency-vehicle traffic control signals; traffic control signals for one-lane, two-way facilities; traffic control signals for freeway entrance ramps; movable bridge traffic signals; toll plaza traffic signals; flashing beacons; lane-use control signals; and in-roadway warning lights.

Section 4A.02 Meanings of Signal Indications

Support:

01 The "Texas Transportation Code" is the primary source for the standards for the meanings of vehicular signal indications to both vehicle operators and pedestrians as provided in Sections 4A.03 and 4A.04, the standards for the meanings of separate bicycle signal face indications as provided in Section 4A.05, and the standards for the meanings of separate pedestrian signal head indications as provided in Section 4A.06.

02 The physical area that is defined as being "within the intersection" is dependent upon the conditions that are described in the definition of an intersection in Section 1C.02.

Section 4A.03 Meanings of Steady Vehicular Signal Indications

Standard:

01 **The following meanings shall be given to steady highway traffic signal indications for vehicles and pedestrians:**

A. Steady green signal indications shall have the following meanings:

1. Vehicular traffic facing a CIRCULAR GREEN signal indication is permitted to proceed straight through or turn right or left or make a U-turn movement except as such movement is modified by lane-use signs, turn prohibition signs, lane markings, roadway design, separate turn signal indications, or other traffic control devices.

Such vehicular traffic, including vehicles turning right or left or making a U-turn movement, shall:

(a) Stop and yield the right-of-way to pedestrians lawfully within an associated crosswalk, and

(b) Yield the right-of-way to other vehicles lawfully using the intersection.

In addition, vehicular traffic turning left or making a U-turn movement to the left shall yield the right-of-way to other vehicles approaching from the opposite direction so closely as to constitute an immediate hazard during the time when such turning vehicle is moving across or within the intersection.

2. Vehicular traffic facing a GREEN ARROW signal indication, displayed alone or in combination with another signal indication, is permitted to cautiously enter the intersection only to make the movement indicated by such arrow, or such other movement as is permitted by other signal indications displayed at the same time.

Such vehicular traffic, including vehicles turning right or left or making a U-turn movement, shall:

(a) Stop and yield the right-of-way to pedestrians lawfully within an associated crosswalk, and

(b) Yield the right-of-way to other vehicles lawfully using the intersection.

3. Pedestrians facing a CIRCULAR GREEN signal indication, unless otherwise directed by a pedestrian signal indication or other traffic control device, are permitted to proceed across the roadway within any marked or unmarked associated crosswalk. The pedestrian shall yield the right-of-way to vehicles lawfully using the intersection or so close as to create an immediate hazard at the time that the green signal indication is first displayed.

4. Pedestrians facing a GREEN ARROW signal indication, unless otherwise directed by a pedestrian signal indication or other traffic control device, shall not cross the roadway.

B. Steady yellow signal indications shall have the following meanings:

1. Vehicular traffic facing a steady CIRCULAR YELLOW signal indication is thereby warned that the related green movement or the related flashing arrow movement is being terminated or that a steady red signal indication will be displayed immediately thereafter when vehicular traffic shall not enter the intersection. The rules set forth concerning vehicular operation under the movement(s) being terminated shall continue to apply while the steady CIRCULAR YELLOW signal indication is displayed.
2. Vehicular traffic facing a steady YELLOW ARROW signal indication is thereby warned that the related GREEN ARROW movement or the related flashing arrow movement is being terminated. The rules set forth concerning vehicular operation under the movement(s) being terminated shall continue to apply while the steady YELLOW ARROW signal indication is displayed.
3. Pedestrians facing a steady CIRCULAR YELLOW or YELLOW ARROW signal indication, unless otherwise directed by a pedestrian signal indication or other traffic control device shall not start to cross the roadway.

C. Steady red signal indications shall have the following meanings:

1. Vehicular traffic facing a steady CIRCULAR RED signal indication, unless entering the intersection to make another movement permitted by another signal indication, shall stop at a clearly marked stop line; but if there is no stop line, traffic shall stop before entering the crosswalk on the near side of the intersection; or if there is no crosswalk, then before entering the intersection; and shall remain stopped until a signal indication to proceed is displayed, or as provided below.

   Except when a traffic control device is in place prohibiting a turn on red, vehicular traffic facing a steady CIRCULAR RED signal indication is permitted to enter the intersection to turn right, or to turn left from a one-way street into a one-way street, after stopping. The right to proceed with the turn shall be subject to the rules applicable after making a stop at a STOP sign.
2. Vehicular traffic facing a steady RED ARROW signal indication, unless entering the intersection to make another movement permitted by another signal indication, shall stop at a clearly marked stop line; but if there is no stop line, before entering the crosswalk on the near side of the intersection; or if there is no crosswalk, then before entering the intersection; and shall remain stopped until a signal indication to proceed is displayed, or as provided below.

   Except when a traffic control device is in place prohibiting a turn on red, vehicular traffic facing a steady RED ARROW signal indication is permitted to enter the intersection to make the movement indicated by the arrow signal indication to turn right, or to turn left from a one-way street into a one-way street, after stopping. The right to proceed with the turn shall be limited to the direction indicated by the arrow and shall be subject to the rules applicable after making a stop at a STOP sign.
3. Unless otherwise directed by a pedestrian signal indication or other traffic control device, pedestrians facing a steady CIRCULAR RED or steady RED ARROW signal indication shall not enter the roadway.

Section 4A.04 Meanings of Flashing Vehicular Signal Indications

Standard:

01 The following meanings shall be given to flashing highway traffic signal indications for vehicles and pedestrians:

A. A flashing green signal indication has no meaning and shall not be used.

B. Flashing yellow signal indications shall have the following meanings:

1. Vehicular traffic, on an approach to an intersection, facing a flashing CIRCULAR YELLOW signal indication is permitted to cautiously enter the intersection to proceed straight through or turn right or left or make a U-turn except as such movement is modified by laneuse signs, turn prohibition signs, lane markings, roadway design, separate turn signal indications, or other traffic control devices.

   Such vehicular traffic, including vehicles turning right or left or making a U-turn, shall:

   (a) Stop and yield the right-of-way to pedestrians lawfully within an associated crosswalk, and

   (b) Yield the right-of-way to other vehicles lawfully using the intersection.

In addition, vehicular traffic turning left or making a U-turn to the left shall yield the right-of-way to other vehicles approaching from the opposite direction so closely as to constitute an immediate hazard during the time when such turning vehicle is moving across or within the intersection.

2. **Vehicular traffic, on an approach to an intersection, facing a flashing YELLOW ARROW signal indication, displayed alone or in combination with another signal indication, is permitted to cautiously enter the intersection only to make the movement indicated by such arrow, or other such movement as is permitted by other signal indications displayed at the same time.**

   Such vehicular traffic, including vehicles turning right or left or making a U-turn, shall yield the right-of-way to:

   (a) Pedestrians lawfully within an associated crosswalk, and

   (b) Other vehicles lawfully using the intersection.

   In addition, vehicular traffic turning left or making a U-turn to the left shall yield the right-of-way to other vehicles approaching from the opposite direction so closely as to constitute an immediate hazard during the time when such turning vehicle is moving across or within the intersection.

3. **Pedestrians facing any flashing yellow signal indication at an intersection, unless otherwise directed by a pedestrian signal indication or other traffic control device, are permitted to proceed across the roadway within any marked or unmarked associated crosswalk. Pedestrians shall yield the right-of-way to vehicles lawfully using the intersection at the time that the flashing yellow signal indication is first displayed.**

4. **When a flashing CIRCULAR YELLOW signal indication(s) is displayed as a beacon (see Chapter 4S) to supplement another traffic control device, road users are notified that there is a need to pay extra attention to the message contained thereon or that the regulatory or warning requirements of the other traffic control device, which might not be applicable at all times, are currently applicable.**

C. **Flashing red signal indications shall have the following meanings:**

1. **Vehicular traffic, on an approach to an intersection, facing a flashing CIRCULAR RED signal indication shall stop at a clearly marked stop line; but if there is no stop line, before entering the crosswalk on the near side of the intersection; or if there is no crosswalk, at the point nearest the intersecting roadway where the driver has a view of approaching traffic on the intersecting roadway before entering the intersection. The right to proceed shall be subject to the rules applicable after making a stop at a STOP sign.**

2. **Vehicular traffic, on an approach to an intersection, facing a flashing RED ARROW signal indication if intending to turn in the direction indicated by the arrow shall stop at a clearly marked stop line; but if there is no stop line, before entering the crosswalk on the near side of the intersection; or if there is no crosswalk, at the point nearest the intersecting roadway where the driver has a view of approaching traffic on the intersecting roadway before entering the intersection. The right to proceed with the turn shall be limited to the direction indicated by the arrow and shall be subject to the rules applicable after making a stop at a STOP sign.**

3. **Pedestrians facing any flashing red signal indication at an intersection, unless otherwise directed by a pedestrian signal indication or other traffic control device, are permitted to proceed across the roadway within any marked or unmarked associated crosswalk. Pedestrians shall yield the right-of-way to vehicles lawfully using the intersection at the time that the flashing red signal indication is first displayed.**

4. **When a flashing CIRCULAR RED signal indication(s) is displayed as a beacon (see Chapter 4S) to supplement another traffic control device, road users are notified that there is a need to pay extra attention to the message contained thereon or that the regulatory requirements of the other traffic control device, which might not be applicable at all times, are currently applicable. Use of this signal indication shall be limited to supplementing STOP (R1-1), DO NOT ENTER (R5-1), or WRONG WAY (R5-1a) signs, and to applications where compliance with the supplemented traffic control device requires a stop at a designated point.**

Section 4A.05 Meanings of Bicycle Symbol Signal Indications

Standard:

01 **The following meanings shall be given to bicycle symbol signal indications for bicyclists:**

A. **Bicyclists facing a steady GREEN BICYCLE signal indication are permitted to enter the intersection only to make the movement indicated by the lane-use arrow(s) displayed on the Bicycle**

Signal sign (see Section 9B.22) that is located immediately adjacent to the signal face. Bicyclists proceeding into the intersection during the display of the steady GREEN BICYCLE signal indication shall: Rev. 1

1. Stop and yield the right-of-way to pedestrians lawfully within an associated crosswalk, and
2. Yield the right-of-way to other vehicles lawfully using the intersection.

B. Bicyclists facing a steady YELLOW BICYCLE signal indication are thereby warned that the related green movement is being terminated and that a steady RED BICYCLE signal indication will be displayed immediately thereafter when bicyclists shall not enter the intersection. The rules set forth concerning bicycle operation under the movement being terminated shall continue to apply while the steady YELLOW BICYCLE signal indication is displayed.

C. Bicyclists facing a steady RED BICYCLE signal indication shall not enter the intersection to make the movement indicated by the lane-use arrow(s) displayed on the Bicycle Signal sign (see Section 9B.22) that is located immediately adjacent to the signal face and, unless entering the intersection to make another movement permitted by another bicycle symbol signal indication, shall stop at a clearly marked stop line; but if there is no stop line, before entering the crosswalk on the near side of the intersection; or if there is no crosswalk, then before entering the intersection; and shall remain stopped until a GREEN BICYCLE signal indication permitting the movement indicated by such RED BICYCLE signal indication is displayed.

Except when a traffic control device is in place prohibiting a turn on red, bicyclists facing a steady RED BICYCLE signal indication are permitted to enter the intersection to turn right if there are no approach lanes for motor vehicle traffic to their right. The right to proceed with the turn shall be subject to the rules applicable after making a stop at a STOP sign.

D. A flashing GREEN BICYCLE signal indication has no meaning and shall not be used.

E. Bicyclists facing a flashing YELLOW BICYCLE signal indication are permitted to cautiously enter the intersection only to make the movement indicated by the lane-use arrow(s) displayed on the Bicycle Signal sign (see Section 9B.22) that is located immediately adjacent to the signal face. Bicyclists proceeding into the intersection during the display of the flashing YELLOW BICYCLE signal indication shall stop and yield the right-of-way to pedestrians lawfully within an associated crosswalk, and yield the right-of-way to other vehicles lawfully using the intersection.

F. Bicyclists facing a flashing RED BICYCLE signal indication shall stop at a clearly marked stop line; but if there is no stop line, before entering the crosswalk on the near side of the intersection; or if there is no crosswalk, at the point nearest the intersecting roadway where the bicyclist has a view of approaching traffic on the intersecting roadway before entering the intersection. The right to proceed in the direction indicated by the lane-use arrow(s) displayed on the Bicycle Signal sign (see Section 9B.22) that is located immediately adjacent to the signal face shall be subject to the rules applicable after making a stop at a STOP sign.

Section 4A.06 Meanings of Pedestrian Signal Indications

Standard:

01 Pedestrian signal indications shall have the following meanings:

A. A flashing WALKING PERSON (symbolizing WALK) signal indication has no meaning and shall not be used.

B. Pedestrians facing a steady WALKING PERSON (symbolizing WALK) signal indication shall be permitted to start to cross the roadway in the direction of the signal indication, possibly in conflict with turning vehicles. Pedestrians shall yield the right-of-way to vehicles lawfully using the intersection at the time that the WALKING PERSON (symbolizing WALK) signal indication is first shown.

C. Pedestrians facing a flashing UPRAISED HAND (symbolizing DONT WALK) signal indication shall not start to cross the roadway in the direction of the signal indication. Any pedestrian who has already started to cross the roadway on a steady WALKING PERSON (symbolizing WALK) signal indication shall continue to proceed to the far side of the traveled way of the street or highway, unless otherwise directed by a traffic control device to proceed only to the median of a divided highway or only to some other island or pedestrian refuge area (see Section 3C.12).

D. Pedestrians facing a steady UPRAISED HAND (symbolizing DONT WALK) signal indication shall not enter the roadway in the direction of the signal indication.

Section 4A.07 Lateral Offset of Signal Supports and Cabinets

Guidance:

01 *The following items should be considered when placing signal supports and cabinets:*

A. *Reference should be made to the "Roadside Design Guide," 4th Edition, 2011, AASHTO, and to the U.S. Department of Justice 2010 ADA Standards for Accessible Design, September 15, 2010, 28 CFR 35 and 36, Americans with Disabilities Act of 1990.*
B. *Signal supports should be placed as far as practicable from the edge of the traveled way without adversely affecting the visibility of the signal indications.*
C. *Where supports cannot be located based on the recommended AASHTO clearances, consideration should be given to the use of appropriate safety devices.*
D. *No part of a concrete foundation for a signal support should extend more than 4 inches above the ground level at any point. This limitation does not apply to the concrete foundation for a rigid support.*
E. *In order to minimize hindrance to the passage of persons with physical disabilities, a signal support or controller cabinet should not obstruct the sidewalk, or access from the sidewalk to the crosswalk.*
F. *Controller cabinets should be located as far as practicable from the edge of the roadway.*
G. *On medians, the minimum clearances provided in Items A through E for signal supports should be obtained, if practicable.*

Section 4A.08 Use of Signs at Signalized Locations

Support:

01 Traffic signal signs are sometimes used at highway traffic signal locations to instruct or guide pedestrians, bicyclists, or motorists. Among the signs typically used at or on the approaches to signalized locations are movement prohibition signs (see Section 2B.26), lane-control signs (see Sections 2B.27 through 2B.29), pedestrian crossing signs (see Section 2B.57), pedestrian and bicycle actuation signs (see Section 2B.58), traffic signal signs (see Sections 2B.59 and 2C.44), No Turn on Red signs (see Section 2B.60), Signal Ahead warning signs (see Section 2C.35), Street Name signs (see Section 2D.45), and Advance Street Name signs (see Section 2D.46).

Guidance:

02 *Regulatory, warning, and guide signs should be used at highway traffic signal locations as provided in Part 2 and as specifically provided elsewhere in Part 4.*

Support:

03 Section 2B.27 contains information regarding the use of overhead lane-control signs on signalized approaches where lane drops, multiple-lane turns involving combined through-and-turn lanes, or other lane-use regulations that would be unexpected by unfamiliar road users are present.

Guidance:

04 *If used, illuminated traffic signal signs should be designed and mounted in such a manner as to avoid glare and reflections that seriously detract from the signal indications. Highway traffic signal faces should be given dominant position and brightness to maximize their priority in the overall display.*

Standard:

05 **The minimum vertical clearance and horizontal offset of the total assembly of traffic signal signs (see Section 2B.59) shall comply with the provisions of Sections 4D.09 and 4D.10.**

06 **STOP signs shall not be used in conjunction with any highway traffic signal operation, except in either of the following cases:**

A. If the signal indication for an approach is a flashing red at all times, or
B. If a minor street or driveway is located within or adjacent to an area controlled by a traffic control signal, but does not require separate traffic signal control because an extremely low potential for conflict exists.

Section 4A.09 Use of Pavement Markings at Signalized Locations

Support:

01 Pavement markings that clearly communicate the operational plan of an intersection to road users play an important role in the effective operation of highway traffic signals. By designating the number of lanes, the use of each lane, the length of additional lanes on the approach to an intersection, crosswalks, and the proper stopping points, the engineer can design the signal phasing and timing to best match the goals of the operational plan.

Guidance:

02 *Pavement markings should be used at highway traffic signal locations as provided in Part 3. If the road surface will not retain pavement markings, signs should be installed to provide the needed road user information.*

Section 4A.10 Responsibility for Operation and Maintenance

Guidance:

01 *Prior to installing any highway traffic signal, the responsibility for the maintenance of the signal and all of the appurtenances, hardware, software, and the timing plan(s) should be clearly established by the responsible agency.*

02 *To this end the agency should:*

- *A. Keep every controller assembly in effective operation in accordance with its predetermined timing schedule, check the operation of the controller assembly frequently enough to verify that it is operating in accordance with the predetermined timing schedule, and establish a policy to maintain a record of all timing changes and that only authorized persons are permitted to make timing changes;*
- *B. Clean the optical system of the signal sections and replace the light sources as frequently as experience proves necessary;*
- *C. Clean and service equipment and other appurtenances as frequently as experience proves necessary;*
- *D. Provide for alternate operation of the traffic control signal during a period of failure, using flashing mode or manual control, or manual traffic direction by proper authorities as might be required by traffic volumes or congestion, or by erecting other traffic control devices;*
- *E. Have properly-skilled maintenance personnel available without undue delay for all signal malfunctions and signal indication failures;*
- *F. Provide spare equipment to minimize the interruption of highway traffic signal operation as a result of equipment failure;*
- *G. Provide for the availability of properly-skilled maintenance personnel for the repair of all components; and*
- *H. Maintain the appearance of the signal displays and equipment.*

CHAPTER 4B. TRAFFIC CONTROL SIGNALS—GENERAL

Section 4B.01 General

Support:

01 Words such as pedestrians and bicyclists are used redundantly in selected Sections of Part 4 to encourage sensitivity to these elements of "traffic."

02 Standards for traffic control signals are important because traffic control signals need to attract the attention of a variety of road users, including those who are older, those with vision disabilities, as well as those who are fatigued or distracted, or who are not expecting to encounter a signal at a particular location.

Section 4B.02 Advantages and Disadvantages of Traffic Control Signals

Support:

01 When properly used, traffic control signals are valuable devices for safety and the control of vehicular and vulnerable road user traffic. They control the various traffic movements by alternating between directing them to stop and permitting them to proceed and thereby profoundly influence traffic flow This accomplishes the need to safely separate road users in time in order to prevent crashes.

02 Traffic control signals that are properly designed, located, operated, and maintained will have one or more of the following advantages:

A. They reduce the frequency and severity of certain types of crashes, especially right-angle collisions and those involving vulnerable road users.
B. They provide for the orderly movement of traffic.
C. They increase the traffic-handling capacity of the intersection if:
   1. Proper physical layouts and control measures are used, and
   2. The signal operational parameters are reviewed and updated (if needed) on a regular basis (as engineering judgment determines that significant traffic flow and/or land use changes have occurred) to maximize the ability of the traffic control signal to satisfy current traffic demands.
D. They are coordinated to provide for continuous or nearly-continuous movement of traffic at a definite speed along a given route under favorable conditions.
E. They are used to interrupt heavy traffic at intervals to permit other traffic, vehicular or pedestrian, to cross.

03 Traffic control signals are often considered a panacea for all traffic problems at intersections.This belief has led to traffic control signals being installed at many locations where they are not needed, adversely affecting the safety and efficiency of motor vehicle, bicycle, and pedestrian traffic.

04 Traffic control signals, even when justified by traffic and roadway conditions, can be ill-designed, ineffectively placed, improperly operated, or poorly maintained. Improper or unjustified traffic control signals can result in one or more of the following disadvantages:

A. Excessive delay,
B. Excessive disobedience of the signal indications,
C. Increased use of less-adequate routes as road users attempt to avoid the traffic control signals, and
D. Significant increases in the frequency of collisions (especially rear-end collisions).

Section 4B.03 Alternatives to Traffic Control Signals

Guidance:

01 *Since road user delay and the frequency of some types of crashes are sometimes higher under traffic signal control than under STOP sign control, consideration should be given to providing alternatives to traffic control signals even if one or more of the signal warrants (see Chapter 4C) has been satisfied.*

Option:

02 These alternatives may include, but are not limited to, the following:

A. Installing signs along the major street to warn road users approaching the intersection;
B. Installing a roundabout to reduce fatal and serious injury crashes and vehicular conflicts that result in fatal and serious injury crashes (see Section 8A.12 if the location is in close proximity to a grade crossing);
C. Installing a pedestrian hybrid beacon (see Chapter 4J), rectangular rapid flashing beacons (see Chapter 4L), pedestrian-actuated Warning Beacons (see Chapter 4S), or In-Roadway Warning Lights (see Chapter 4U) if pedestrian safety is the major concern;
D. Relocating the stop line(s) and making other changes to improve the sight distance at the intersection;

E. Installing measures designed to reduce speeds on the approaches;
F. Installing a flashing beacon at the intersection to supplement STOP sign control;
G. Installing flashing beacons on warning signs in advance of a stop-controlled intersection on the major-street and/or minor-street approaches;
H. Adding one or more lanes on a minor-street approach to reduce the number of vehicles per lane on the approach;
I. Revising the geometrics at the intersection to channelize vehicular movements and reduce the time required for a vehicle to complete a movement, which could also assist pedestrians;
J. Revising the geometrics at the intersection to add pedestrian median refuge islands and/or curb extensions;
K. Installing roadway lighting if a disproportionate number of crashes occur at night;
L. Restricting one or more turning movements, perhaps on a time-of-day basis, if alternate routes are available;
M. If the warrant is satisfied, installing multi-way stop control;
N. Employing other alternatives, depending on conditions at the intersection.

Section 4B.04 Basis of Installation of Traffic Control Signals

Support:

01 A careful analysis of traffic operations, pedestrian and bicyclist needs, and other factors at a large number of signalized and unsignalized locations, coupled with engineering judgment, has provided a series of signal warrants, described in Chapter 4C, that define the minimum conditions under which installing traffic control signals might be justified.

Guidance:

02 *The design (including the phasing, operation, and timing) of new traffic control signals should be based on an engineering study of roadway, traffic, and other conditions.*

Section 4B.05 Basis of Removal of Traffic Control Signals

Guidance:

01 *Engineering judgment should be applied in the review of operating traffic control signals to determine whether the type of installation and the timing program meet the current requirements of all forms of traffic.*

02 *If changes in traffic patterns eliminate the need for a traffic control signal, consideration should be given to removing it and replacing it with appropriate alternative traffic control devices, if any are needed.*

03 *If the engineering study indicates that the traffic control signal is no longer justified, and a decision is made to remove the signal, the removal should be accomplished using the following steps:*

A. Determine the appropriate traffic control to be used after the removal of the signal.
B. Remove any sight-distance restrictions as necessary.
C. Inform the public of the removal study.
D. Flash or cover the signal heads for a minimum of 90 days, and install the appropriate STOP sign control or other traffic control devices.
E. Remove the signal if the engineering data collected during the removal study period confirms that the signal is no longer needed.

Option:

04 Because Items C, D, and E in Paragraph 3 of this Section are not relevant when a temporary traffic control signal (see Section 4D.11) is removed, a temporary traffic control signal may be removed immediately after Items A and B are completed.

05 Instead of total removal of a traffic control signal, the poles, controller cabinet, and cables may remain in place after removal of the signal heads for continued analysis.

CHAPTER 4C. TRAFFIC CONTROL SIGNAL NEEDS STUDIES

Section 4C.01 Studies and Factors for Justifying Traffic Control Signals

Standard:

01 **Except for a temporary traffic control signal (see Section 4D.11) installed in a temporary traffic control zone, before a traffic control signal is installed at a particular location, an engineering study of traffic conditions, pedestrian characteristics, and physical characteristics of the location shall be performed to determine whether installation of a traffic control signal is justified at that location.**

02 **The investigation of the need for a traffic control signal shall include an analysis of factors related to the existing operation and safety at the study location and the potential to improve these conditions, and the applicable factors contained in the following traffic signal warrants:**

Warrant 1, Eight-Hour Vehicular Volume
Warrant 2, Four-Hour Vehicular Volume
Warrant 3, Peak Hour
Warrant 4, Pedestrian Volume
Warrant 5, School Crossing
Warrant 6, Coordinated Signal System
Warrant 7, Crash Experience
Warrant 8, Roadway Network
Warrant 9, Intersection Near a Grade Crossing

03 **The satisfaction of a traffic signal warrant or warrants shall not in itself require the installation of a traffic control signal.**

Support:

04 Sections 8D.08 and 8D.14 contain information regarding the use of traffic control signals instead of gates and/or flashing-light signals at grade crossings.

Guidance:

05 *When considering the installation of a traffic control signal, alternatives to traffic control signals, including those listed in Section 4B.03, should also be considered.*

06 *A traffic control signal should not be installed unless one or more of the factors described in this Chapter are met.*

07 *A traffic control signal should not be installed unless an engineering study indicates that installing a traffic control signal will improve the overall safety and/or operation of the intersection.*

08 *The study should consider the effects of the right-turning vehicles from the minor-street approaches. Engineering judgment should be used to determine what, if any, portion of the right-turning traffic is subtracted from the minor-street traffic count when evaluating the count against the signal warrants listed in Paragraph 2 of this Section.*

09 *Engineering judgment should also be used in applying various traffic signal warrants to cases where major-street approaches consist of one lane plus one left-turn or right-turn lane. The site-specific traffic characteristics should dictate whether a major-street approach is considered as one lane or two lanes. For example, for a major-street approach with one lane for through and right-turning traffic plus a left-turn lane, if engineering judgment indicates that it should be considered a one-lane approach because the traffic using the left-turn lane is minor, the total traffic volume approaching the intersection should be applied against the signal warrants as a one-lane approach. The major-street approach should be considered two lanes if approximately half of the traffic on the approach turns left and the left-turn lane is of sufficient length to accommodate all left-turning vehicles.*

10 *Similar engineering judgment and rationale should be applied to a minor-street approach with one through/left-turn lane plus a right-turn lane. In this case, the degree of conflict of minor-street right-turning traffic with traffic on the major street should be considered. Thus, right-turning traffic should not be included in the minor-street volume if the movement enters the major street with minimal conflict. The minor-street approach should be evaluated as a one-lane approach with only the traffic volume in the through/left-turn lane considered.*

11 *If a minor-street approach has one combined through/right-turn lane plus a left-turn lane, the approach should either be analyzed as a two-lane approach based on the sum of the traffic volumes using both lanes or as a one-lane approach based on only the traffic volume in the approach lane with the higher volume.*

12 *At a location that is under development or construction or at a location where it is not possible to obtain a traffic count that would represent future traffic conditions, hourly volumes should be estimated as part of an engineering study for comparison with traffic signal warrants. Except for locations where the engineering study*

uses the satisfaction of Warrant 8 to justify a signal, a traffic control signal installed under projected conditions should have an engineering study done within 1 year of putting the signal into steady (stop-and-go) operation to determine if the signal is justified. If not justified, the signal should be taken out of steady (stop-and-go) operation or removed.

Option:

13 For signal warrant analysis, a location with a wide median may be analyzed as one intersection or as two intersections (see Section 2A.23) based on engineering judgment.

14 At an intersection with a high volume of left-turning traffic from the major street, the signal warrant analysis may be performed in a manner that considers the higher of the major-street left-turn volumes as the "minor-street" volume and the corresponding single direction of opposing traffic on the major street as the "major-street" volume.

15 For signal warrants requiring conditions to be present for a certain number of hours in order to be satisfied, any four consecutive 15-minute periods may be considered as 1 hour if the separate 1-hour periods used in the warrant analysis do not overlap each other and both the major-street volume and the minor-street volume are for the same specific 1-hour periods.

16 For signal warrant analysis, bicyclists may be counted as either vehicles or pedestrians.

Support:

17 When performing a signal warrant analysis, bicyclists riding in the street with other vehicular traffic are usually counted as vehicles and bicyclists who are clearly using pedestrian facilities are usually counted as pedestrians.

Option:

18 Engineering study data may include the following:

A. The number of vehicles entering the intersection in each hour from each approach during 12 hours of an average day. It is desirable that the hours selected contain the greatest percentage of the 24-hour traffic volume.
B. Vehicular volumes for each traffic movement from each approach, classified by vehicle type (heavy trucks, passenger cars and light trucks, public-transit vehicles, and, in some locations, bicycles), during each 15-minute period of the 2 hours in the morning and 2 hours in the afternoon during which the total traffic entering the intersection is the greatest.
C. Pedestrian volume counts on each crosswalk during the same periods as the vehicular counts in Item B and during the hours of highest pedestrian volume. Where young, elderly, and/or persons with physical or vision disabilities need special consideration, the pedestrians and their crossing times may be classified by general observation.
D. Information about nearby facilities and activity centers that serve the young, elderly, and/or persons with disabilities, including requests from persons with disabilities for accessible crossing improvements at the location under study. These persons might not be adequately reflected in the pedestrian volume count if the absence of a signal restrains their mobility.
E. The posted or statutory speed limit or the 85th-percentile speed on the uncontrolled approaches to the location.
F. A condition diagram showing details of the physical layout, including such features as intersection geometrics, channelization, grades, sight-distance restrictions, transit stops and routes, parking conditions, pavement markings, roadway lighting, driveways, nearby railroad crossings, distance to the nearest traffic control signals, utility poles and fixtures, and adjacent land use.
G. A collision diagram showing crash experience by type, location, direction of movement, severity, weather, time of day, date, and day of week for at least 1 year.

19 The following data, which are desirable for a more precise understanding of the operation of the intersection, may be obtained during the periods described in Item B of Paragraph 18 of this Section:

A. Vehicle-hours of stopped-time delay determined separately for each approach.
B. The number and distribution of acceptable gaps in vehicular traffic on the major street for entrance from the minor street.
C. The posted or statutory speed limit or the 85th-percentile speed on controlled approaches at a point near to the intersection but unaffected by the control.
D. Pedestrian delay time for at least two 30-minute peak pedestrian delay periods of an average weekday or like periods of a Saturday or Sunday.
E. Queue length on stop-controlled approaches.

Support:

20 The safe and efficient movement of all road users is the primary consideration in the engineering study to determine whether to install a traffic control signal or to install some other type of control or roadway configuration. Installation of a traffic control signal does not necessarily result in improved safety in every case. In some cases, the installation of a traffic control signal at an inappropriate location could adversely impact safety for one or more types of road users. The purpose of the engineering study is to evaluate all of the factors that are relevant to a specific location. The satisfaction of a warrant (or warrants) is one of the relevant factors in the engineering study, but it is not intended to be the only factor or even the overriding consideration. Agencies can install a traffic control signal at a location where no warrants are met, but only after conducting an engineering study that documents the rationale for deciding that the installation of a traffic control signal is the best solution for improving the overall safety and/or operation at the location.

Section 4C.02 Warrant 1, Eight-Hour Vehicular Volume

Support:

01 The Minimum Vehicular Volume, Condition A (see Table 4C-1), is intended for application at locations where a large volume of intersecting traffic is the principal reason to consider installing a traffic control signal.

02 The Interruption of Continuous Traffic, Condition B (see Table 4C-1), is intended for application at locations where Condition A is not satisfied and where the traffic volume on a major street is so heavy that traffic on a minor intersecting street suffers excessive delay or conflict in entering or crossing the major street.

03 It is intended that Warrant 1 be treated as a single warrant. If Condition A is satisfied, then Warrant 1 is satisfied and analyses of Condition B and the combination of Conditions A and B are not needed. Similarly, if Condition B is satisfied, then Warrant 1 is satisfied and an analysis of the combination of Conditions A and B is not needed.

Guidance:

04 *The need for a traffic control signal should be considered if an engineering study finds that one of the following conditions exist for each of any 8 hours of an average day:*

- *A. The vehicles per hour given in both of the 100 percent columns of Condition A in Table 4C-1 exist on the major street and the more critical minor-street approach, respectively, to the intersection; or*
- *B. The vehicles per hour given in both of the 100 percent columns of Condition B in Table 4C-1 exist on the major street and the more critical minor-street approach, respectively, to the intersection.*

Standard:

05 **These major-street and minor-street volumes shall be for the same 8 hours for each condition; however, the 8 hours that are selected for the Condition A analysis shall not be required to be the same 8 hours that are selected for the Condition B analysis.**

Support:

06 On the minor street, the more critical volume is not required to be on the same approach during each of these 8 hours. The more critical minor-street volume is the one that meets the warranting criteria for that approach, and in the case of a one-lane minor-street approach that is opposite from a multi-lane minor-street approach might not have the higher volume.

Option:

07 If the posted or statutory speed limit or the 85th-percentile speed on the major street exceeds 40 mph, or if the intersection lies within the built-up area of an isolated community having a population of less than 10,000, the traffic volumes in the 70 percent columns in Table 4C-1 may be used in place of the 100 percent columns.

Guidance:

08 *The combination of Conditions A and B is intended for application at locations where Condition A is not satisfied and Condition B is not satisfied and should be applied only after an adequate trial of other alternatives that could cause less delay and inconvenience to traffic has failed to solve the traffic problems.*

09 *The need for a traffic control signal should be considered if an engineering study finds that both of the following conditions exist for each of any 8 hours of an average day:*

- *A. The vehicles per hour given in both of the 80 percent columns of Condition A in Table 4C-1 exist on the major street and the more critical minor-street approach, respectively, to the intersection; and*
- *B. The vehicles per hour given in both of the 80 percent columns of Condition B in Table 4C-1 exist on the major street and the more critical minor-street approach, respectively, to the intersection.*

Standard:

10 **These major-street and minor-street volumes shall be for the same 8 hours for each condition; however, the 8 hours satisfied in Condition A shall not be required to be the same 8 hours satisfied in Condition B.**

Support:

11 On the minor street, the more critical volume is not required to be on the same approach during each of the 8 hours. The more critical minor-street volume is the one that meets the warranting criteria for that approach, and in the case of a one-lane minor-street approach that is opposite from a multi-lane minor-street approach might not have the higher volume.

Option:

12 If the posted or statutory speed limit or the 85th-percentile speed on the major street exceeds 40 mph, or if the intersection lies within the built-up area of an isolated community having a population of less than 10,000, the traffic volumes in the 56 percent columns in Table 4C-1 may be used in place of the 80 percent columns.

Table 4C-1. Warrant 1, Eight-Hour Vehicular Volume

Condition A—Minimum Vehicular Volume

Number of lanes for moving traffic on each approach		Vehicles per hour on major street (total of both approaches)				Vehicles per hour on more critical minor-street approach (one direction only)			
Major Street	Minor Street	100%[a]	80%[b]	70%[c]	56%[d]	100%[a]	80%[b]	70%[c]	56%[d]
1	1	500	400	350	280	150	120	105	84
2 or more	1	600	480	420	336	150	120	105	84
2 or more	2 or more	600	480	420	336	200	160	140	112
1	2 or more	500	400	350	280	200	160	140	112

Condition B - Interruption of Continuous Traffic

Number of lanes for moving traffic on each approach		Vehicles per hour on major street (total of both approaches)				Vehicles per hour on more critical minor-street approach (one direction only)			
Major Street	Minor Street	100%[a]	80%[b]	70%[c]	56%[d]	100%[a]	80%[b]	70%[c]	56%[d]
1	1	750	600	525	420	75	60	53	42
2 or more	1	900	720	630	504	75	60	53	42
2 or more	2 or more	900	720	630	504	100	80	70	56
1	2 or more	750	600	525	420	100	80	70	56

[a] **Basic minimum hourly volume**

[b] **Used for combination of Conditions A and B after adequate trial of other remedial measures**

[c] **May be used when the major-street speed exceeds 40 mph or in an isolated community with a population of less than 10,000**

[d] **May be used for combination of Conditions A and B after adequate trial of other remedial measures when the major-street speed exceeds 40 mph or in an isolated community with a population of less than 10,000**

Section 4C.03 Warrant 2, Four-Hour Vehicular Volume

Support:

01 The Four-Hour Vehicular Volume signal warrant conditions are intended to be applied where the volume of intersecting traffic is the principal reason to consider installing a traffic control signal.

Guidance:

02 *The need for a traffic control signal should be considered if an engineering study finds that, for each of any 4 hours of an average day, the plotted points representing the vehicles per hour on the major street (total of both approaches) and the corresponding vehicles per hour on the more critical minor-street approach (one direction only) all fall above the applicable curve in Figure 4C-1 for the existing combination of approach lanes.*

Support:

03 On the minor street, the more critical volume is not required to be on the same approach during each of these 4 hours. The more critical minor-street volume is the one that meets the warranting criteria for that approach, and in the case of a one-lane minor-street approach that is opposite from a multi-lane minor-street approach might not have the higher volume.

Option:

04 If the posted or statutory speed limit or the 85th-percentile speed on the major street exceeds 40 mph, or if the intersection lies within the built-up area of an isolated community having a population of less than 10,000, Figure 4C-2 may be used in place of Figure 4C-1.

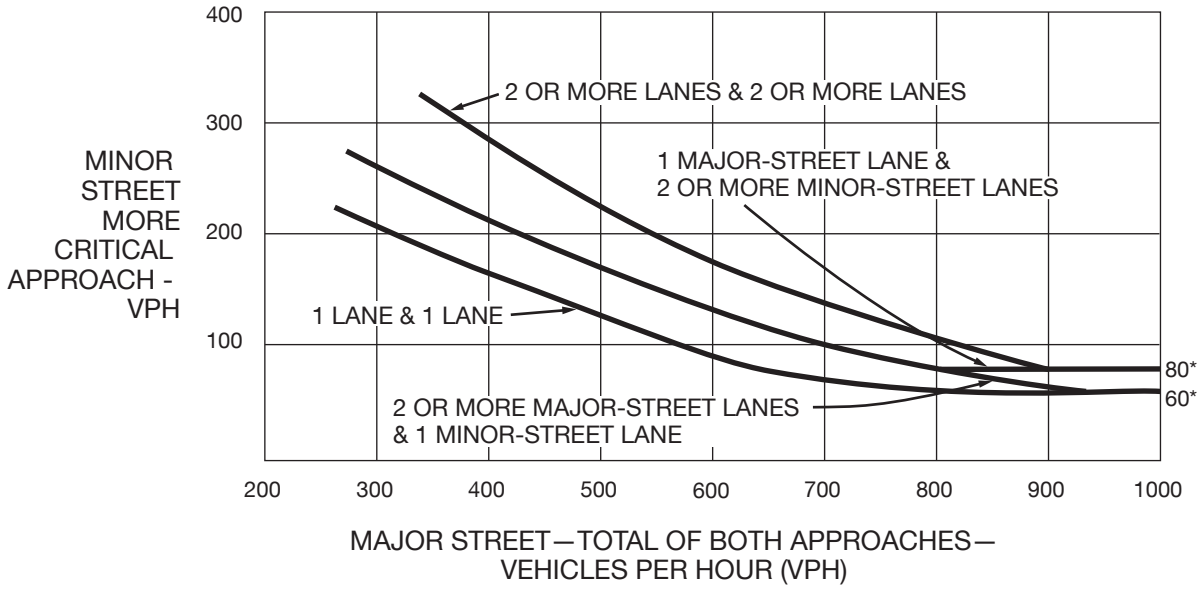
Figure 4C-1. Warrant 2, Four-Hour Vehicular Volume



*Note: 115 vph applies as the lower threshold volume for a minor-street approach with two or more lanes and 80 vph applies as the lower threshold volume for a minor-street approach with one lane

Figure 4C-2. Warrant 2, Four-Hour Vehicular Volume (70% Factor)

(COMMUNITY LESS THAN 10,000 POPULATION OR ABOVE 40 MPH ON MAJOR STREET)



*Note: 80 vph applies as the lower threshold volume for a minor-street approach with two or more lanes and 60 vph applies as the lower threshold volume for a minor-street approach with one lane

Section 4C.04 Warrant 3, Peak Hour

Support:

01 The Peak Hour signal warrant is intended for use at a location where traffic conditions are such that for a minimum of 1 hour of an average day, the minor-street traffic suffers undue delay when entering or crossing the major street.

Guidance:

02 *This signal warrant should be applied only in unusual cases, such as office complexes, manufacturing plants, industrial complexes, or high-occupancy vehicle facilities that attract or discharge large numbers of vehicles over a short time.*

03 *The need for a traffic control signal should be considered if an engineering study finds that the criteria in either of the following two categories are met:*

A. If all three of the following conditions exist for the same 1 hour (any four consecutive 15-minute periods) of an average day:

1. The total stopped-time delay experienced by the traffic on one minor-street approach (one direction only) controlled by a STOP sign equals or exceeds: 4 vehicle-hours for a one-lane approach or 5 vehicle-hours for a two-lane approach, and

2. The volume on the same minor-street approach (one direction only) equals or exceeds 100 vehicles per hour for one moving lane of traffic or 150 vehicles per hour for two moving lanes, and

3. The total entering volume serviced during the hour equals or exceeds 650 vehicles per hour for intersections with three approaches or 800 vehicles per hour for intersections with four or more approaches.

B. The plotted point representing the vehicles per hour on the major street (total of both approaches) and the corresponding vehicles per hour on the more critical minor-street approach (one direction only) for 1 hour (any four consecutive 15-minute periods) of an average day falls above the applicable curve in Figure 4C-3 for the existing combination of approach lanes.

Option:

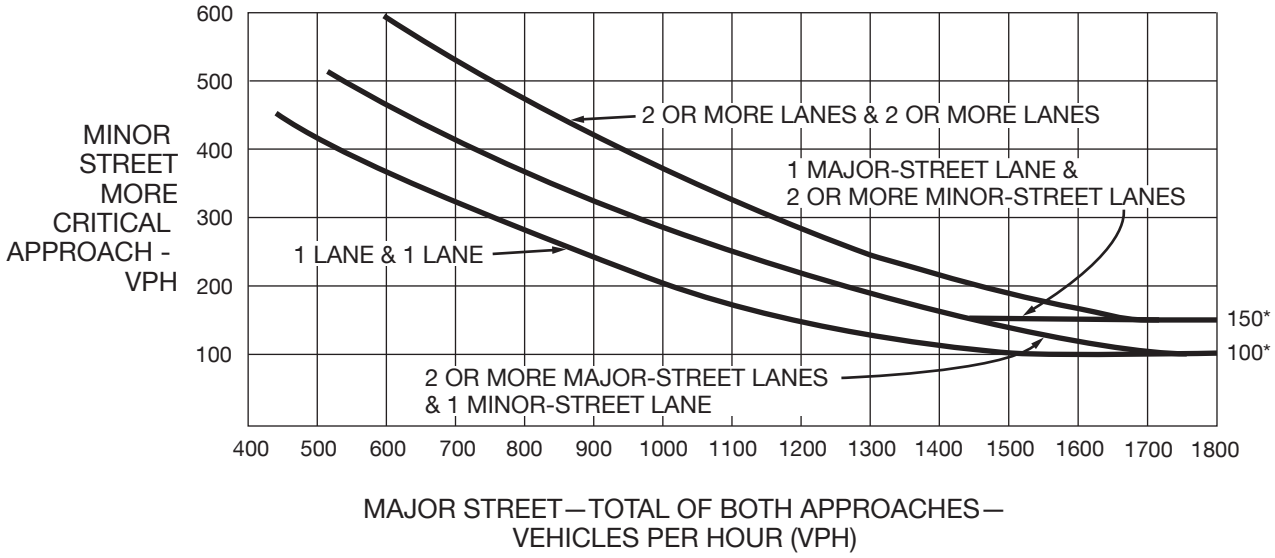
04 If the posted or statutory speed limit or the 85th-percentile speed on the major street exceeds 40 mph, or if the intersection lies within the built-up area of an isolated community having a population of less than 10,000, Figure 4C-4 may be used in place of Figure 4C-3 to evaluate the criteria in Item B of Paragraph 3 in this Section.

05 If this warrant is the only warrant met and a traffic control signal is justified by an engineering study, the traffic control signal may be operated in the flashing mode during the hours that the volume criteria of this warrant are not met.

Guidance:

06 *If this warrant is the only warrant met and a traffic control signal is justified by an engineering study, the traffic control signal should be traffic-actuated.*

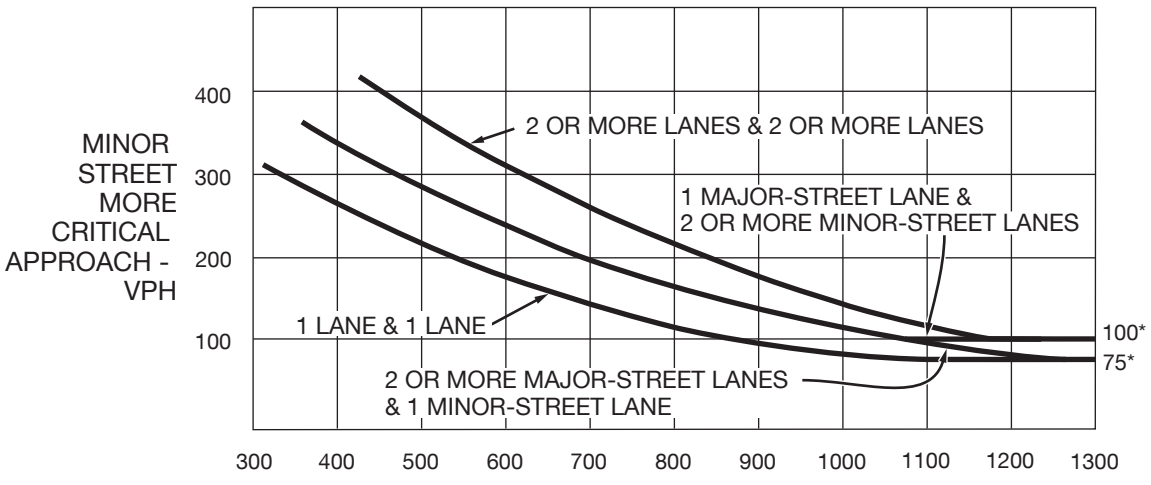
Figure 4C-3. Warrant 3, Peak Hour



*Note: 150 vph applies as the lower threshold volume for a minor-street approach with two or more lanes and 100 vph applies as the lower threshold volume for a minor-street approach with one lane

Figure 4C-4. Warrant 3, Peak Hour (70% Factor)

(COMMUNITY LESS THAN 10,000 POPULATION OR ABOVE 40 MPH ON MAJOR STREET)



*Note: 100 vph applies as the lower threshold volume for a minor-street approach with two or more lanes and 75 vph applies as the lower threshold volume for a minor-street approach with one lane

Section 4C.05 Warrant 4, Pedestrian Volume

Support:

01 The Pedestrian Volume signal warrant is intended for application where the traffic volume on a major street is so heavy that pedestrians experience excessive delay in crossing the major street.

Guidance:

02 *The need for a traffic control signal at an intersection or midblock crossing should be considered if an engineering study finds that one of the following criteria is met:*

- *A. For each of any 4 hours of an average day, the plotted points representing the vehicles per hour on the major street (total of both approaches) and the corresponding pedestrians per hour crossing the major street (total of all crossings) all fall above the curve in Figure 4C-5; or*
- *B. For 1 hour (any four consecutive 15-minute periods) of an average day, the plotted point representing the vehicles per hour on the major street (total of both approaches) and the corresponding pedestrians per hour crossing the major street (total of all crossings) falls above the curve in Figure 4C-6.*

Option:

03 If the posted or statutory speed limit or the 85th-percentile speed on the major street exceeds 35 mph, or if the intersection lies within the built-up area of an isolated community having a population of less than 10,000, Figure 4C-7 may be used in place of Figure 4C-5 to evaluate Item A in Paragraph 2 of this Section, and Figure 4C-8 may be used in place of Figure 4C-6 to evaluate Item B in Paragraph 2 of this Section.

04 Where there is a divided street having a median of sufficient width for pedestrians to wait, the criteria in Items A and B of Paragraph 2 of this Section may be applied separately to each direction of vehicular traffic.

Guidance:

05 *The Pedestrian Volume signal warrant should not be applied at locations where the distance to the nearest traffic control signal or STOP sign controlling the street that pedestrians desire to cross is less than 300 feet, unless the proposed traffic control signal will not restrict the progressive movement of traffic.*

Standard:

06 **If this warrant is met and a traffic control signal is justified by an engineering study, the traffic control signal shall be equipped with pedestrian signal heads complying with the provisions set forth in Chapter 4I.**

Guidance:

07 *If this warrant is met and a traffic control signal is justified by an engineering study, then:*

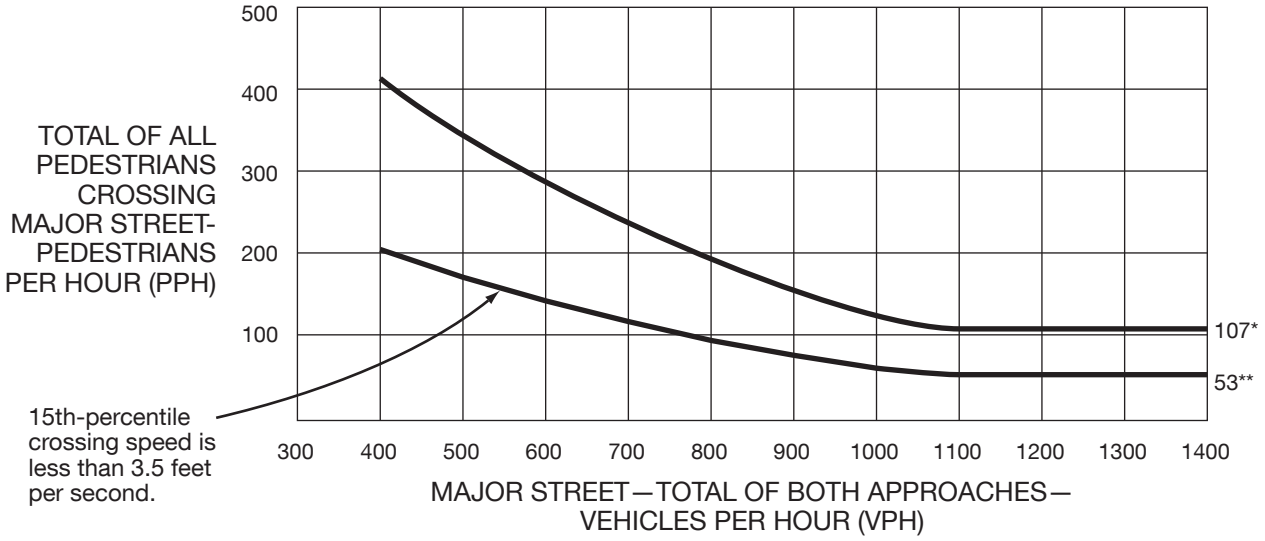
- *A. If it is installed at an intersection or major driveway location, the traffic control signal should also control the minor-street or driveway traffic, should be traffic-actuated, and should include pedestrian detection.*
- *B. If it is installed at a non-intersection crossing, the traffic control signal should be installed at least 100 feet from side streets or driveways that are controlled by STOP or YIELD signs, and should be pedestrian-actuated. If the traffic control signal is installed at a non-intersection crossing, at least one of the signal faces should be over the traveled way for each approach, parking and other sight obstructions should be prohibited for at least 100 feet in advance of and at least 20 feet beyond the crosswalk or site accommodations should be made through curb extensions or other techniques to provide adequate sight distance, and the installation should include suitable standard signs and pavement markings.*
- *C. Furthermore, if it is installed within a signal system, the traffic control signal should be coordinated.*

Option:

08 The criterion for the pedestrian volume crossing the major street may be reduced as much as 50 percent if the 15th-percentile crossing speed of pedestrians is less than 3.5 feet per second (see Figures 4C-5 through 4C-8).

09 A traffic control signal may not be needed at the study location if adjacent coordinated traffic control signals consistently provide gaps of adequate length for pedestrians to cross the street.

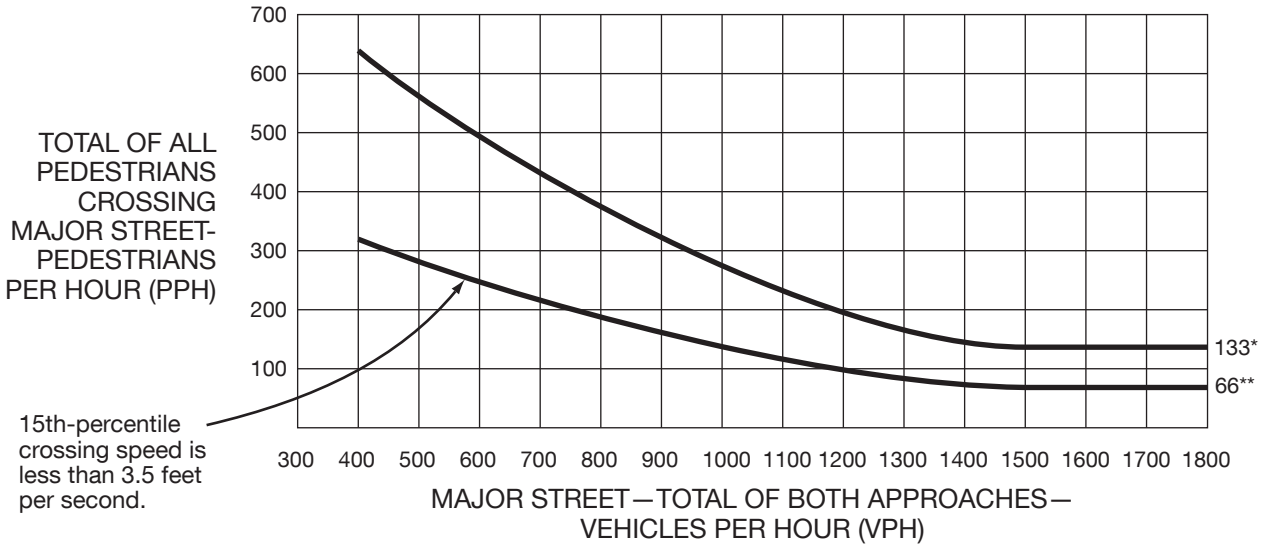
Figure 4C-5. Warrant 4, Pedestrian Four-Hour Volume



* 107 pph applies as the lower threshold volume

** 53 pph applies as the lower threshold volume if the 15th-percentile crossing speed is less than 3.5 feet per second

Figure 4C-6. Warrant 4, Pedestrian Peak Hour

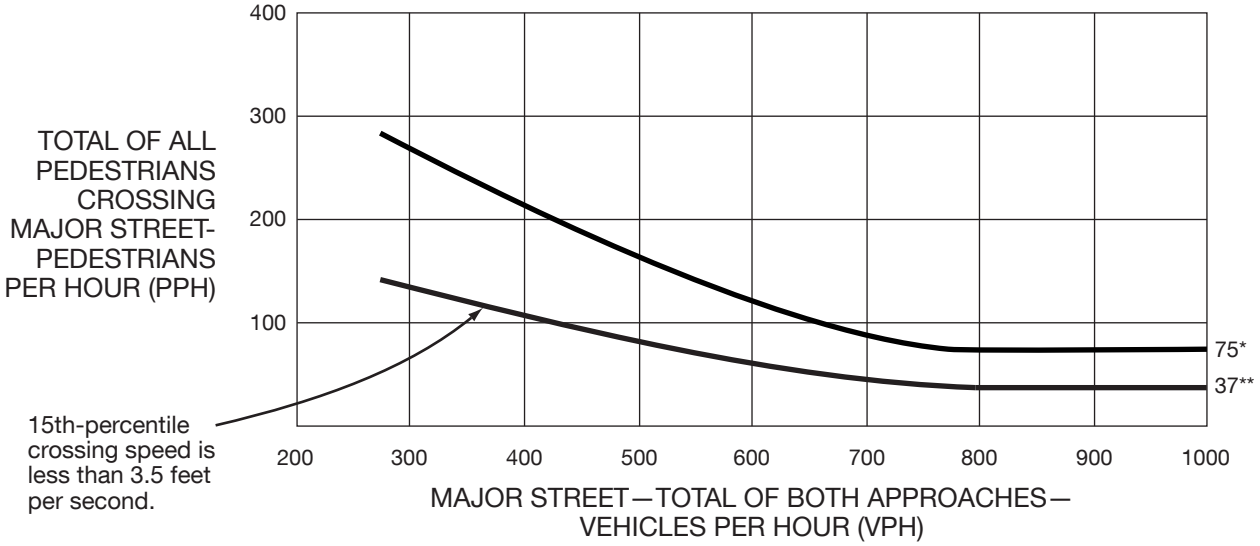


* 133 pph applies as the lower threshold volume

** 66 pph applies as the lower threshold volume if the 15th-percentile crossing speed is less than 3.5 feet per second

Figure 4C-7. Warrant 4, Pedestrian Four-Hour Volume (70% Factor)

(COMMUNITY LESS THAN 10,000 POPULATION OR ABOVE 35 MPH ON MAJOR STREET)

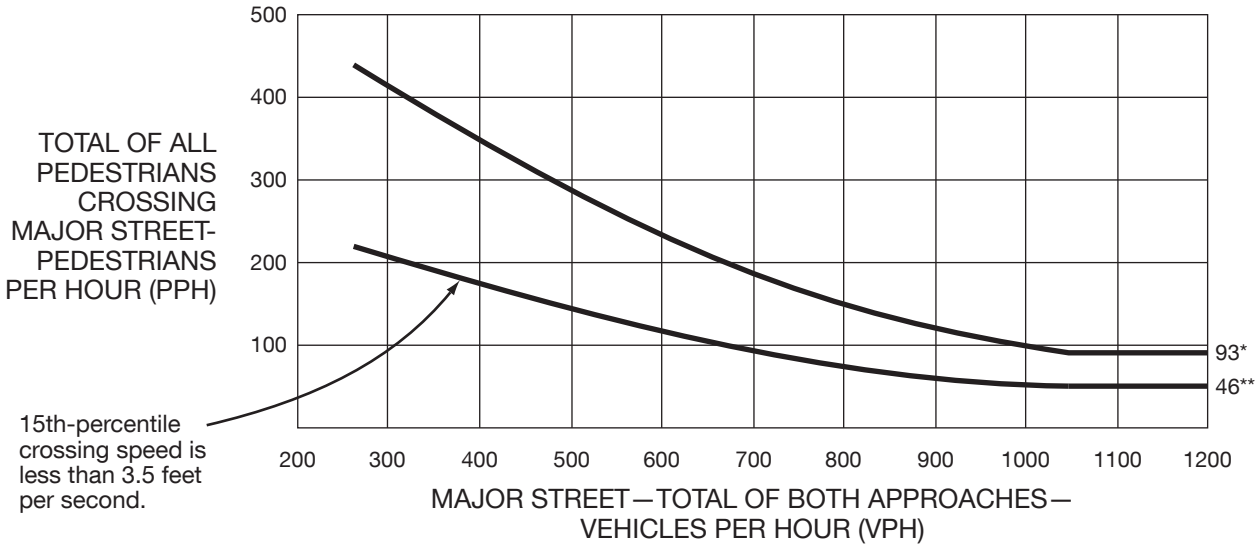


* 75 pph applies as the lower threshold volume

** 37 pph applies as the lower threshold volume if the 15th-percentile crossing speed is less than 3.5 feet per second

Figure 4C-8. Warrant 4, Pedestrian Peak Hour (70% Factor)

(COMMUNITY LESS THAN 10,000 POPULATION OR ABOVE 35 MPH ON MAJOR STREET)



* 93 pph applies as the lower threshold volume

** 46 pph applies as the lower threshold volume if the 15th-percentile crossing speed is less than 3.5 feet per second

Section 4C.06 Warrant 5, School Crossing

Support:

01 The School Crossing signal warrant is intended for application where the fact that schoolchildren cross the major street is the principal reason to consider installing a traffic control signal. For the purposes of this warrant, the word "schoolchildren" includes elementary through high school students.

Guidance:

02 *The need for a traffic control signal should be considered when an engineering study of the frequency and adequacy of gaps in the vehicular traffic stream as related to the number and size of groups of schoolchildren at an established school crossing across the major street shows that the number of adequate gaps in the traffic stream during the period when the schoolchildren are using the crossing is less than the number of minutes in the same period and there are a minimum of 20 schoolchildren during the highest crossing hour.*

03 *Before a decision is made to install a traffic control signal, consideration should be given to the implementation of other remedial measures, such as warning signs and flashers, school speed zones, school crossing guards, or a grade-separated crossing.*

04 *The School Crossing signal warrant should not be applied at locations where the distance to the nearest traffic control signal along the major street is less than 300 feet, unless the proposed traffic control signal will not restrict the progressive movement of traffic.*

Standard:

05 **If this warrant is met and a traffic control signal is justified by an engineering study, the traffic control signal shall be equipped with pedestrian signal heads complying with the provisions set forth in Chapter 4I.**

Guidance:

06 *If this warrant is met and a traffic control signal is justified by an engineering study, then:*

- *A. If it is installed at an intersection or major driveway location, the traffic control signal should also control the minor-street or driveway traffic, should be traffic-actuated, and should include pedestrian detection.*
- *B. If it is installed at a non-intersection crossing, the traffic control signal should be installed at least 100 feet from side streets or driveways that are controlled by STOP or YIELD signs, and should be pedestrian-actuated. If the traffic control signal is installed at a non-intersection crossing, at least one of the signal faces should be over the traveled way for each approach, parking and other sight obstructions should be prohibited for at least 100 feet in advance of and at least 20 feet beyond the crosswalk or site accommodations should be made through curb extensions or other techniques to provide adequate sight distance, and the installation should include suitable standard signs and pavement markings.*
- *C. Furthermore, if it is installed within a signal system, the traffic control signal should be coordinated.*

Section 4C.07 Warrant 6, Coordinated Signal System

Support:

01 Progressive movement in a coordinated signal system sometimes necessitates installing traffic control signals at intersections where they would not otherwise be needed in order to maintain proper platooning of vehicles.

Guidance:

02 *The need for a traffic control signal should be considered if an engineering study finds that one of the following criteria is met:*

- *A. On a one-way street or a street that has traffic predominantly in one direction, the adjacent traffic control signals are so far apart that they do not provide the necessary degree of vehicular platooning.*
- *B. On a two-way street, adjacent traffic control signals do not provide the necessary degree of platooning and the proposed and adjacent traffic control signals will collectively provide a progressive operation.*

03 *The Coordinated Signal System signal warrant should not be applied where the resultant spacing of traffic control signals would be less than 1,000 feet.*

Section 4C.08 Warrant 7, Crash Experience

Support:

01 The Crash Experience signal warrant conditions are intended for application where the severity and frequency of crashes are the principal reasons to consider installing a traffic control signal.

Guidance:

02 *The need for a traffic control signal should be considered if an engineering study finds that all of the following criteria are met:*

- *A. Adequate trial of alternatives with satisfactory observance and enforcement has failed to reduce the crash frequency; and*
- *B. At least one of the following conditions applies to the reported crash history (where each reported crash considered is related to the intersection and apparently exceeds the applicable requirements for a reportable crash):*
  - *1. The number of reported angle crashes and pedestrian crashes within a 1-year period equals or exceeds the threshold number in Table 4C-2 for total angle crashes and pedestrian crashes (all severities); or*
  - *2. The number of reported fatal-and-injury angle crashes and pedestrian crashes within a 1-year period equals or exceeds the threshold number in Table 4C-2 for total fatal-and-injury angle crashes and pedestrian crashes; or*
  - *3. The number of reported angle crashes and pedestrian crashes within a 3-year period equals or exceeds the threshold number in Table 4C-3 for total angle crashes and pedestrian crashes (all severities); or*
  - *4. The number of reported fatal-and-injury angle crashes and pedestrian crashes within a 3-year period equals or exceeds the threshold number in Table 4C-3 for total fatal-and-injury angle crashes and pedestrian crashes; and*
- *C. For each of any 8 hours of an average day, the vehicles per hour (vph) given in both of the 80 percent columns of Condition A in Table 4C-1 (see Section 4C.02), or the vph in both of the 80 percent columns of Condition B in Table 4C-1 exists on the major street and the more critical minor-street approach, respectively, to the intersection, or the volume of pedestrian traffic is not less than 80 percent of the requirements specified in the Pedestrian Volume warrant (see Section 4C.05).*

Standard:

03 **These major-street and minor-street volumes shall be for the same 8 hours.**

Support:

04 On the minor street, the more critical volume is not required to be on the same approach during each of these 8 hours. The more critical minor-street volume is the one that meets the warranting criteria for that approach, and in the case of a one-lane minor-street approach that is opposite from a multi-lane minor-street approach might not have the higher volume.

Option:

05 If the posted or statutory speed limit or the 85th-percentile speed on the major street exceeds 40 mph, or if the intersection lies within the built-up area of an isolated community having a population of less than 10,000:

- A. The traffic volumes in the 56 percent columns in Table 4C-1 may be used in place of the 80 percent columns.
- B. Tables 4C-4 and 4C-5 may be used in place of Tables 4C-2 and 4C-3, respectively.

Option:

06 Agencies may calibrate Highway Safety Manual (HSM) (AASHTO, 2010) safety performance functions (SPFs) to their own crash data or develop their own SPFs to produce agency specific average crash frequency values. When documented as part of the engineering study, these agency specific crash frequency values may be used instead of the values shown in Tables 4C-2 through 4C-5 when applying the Crash Experience signal warrant.

Support:

07 The values in Tables 4C-2 through 4C-5 for Minimum Number of Reported Crashes that correspond to the Crash Experience signal warrant were derived using the safety performance functions (SPFs) in the Highway Safety Manual (HSM) (AASHTO, 2010) for stop-controlled and signalized intersections with characteristics that are considered typical. The values in Tables 4C-2 through 4C-5 are representative of average crash frequency for the given intersection condition. The values correspond to the threshold at which the signalized intersection safety performance outperforms the stop-controlled intersection, for otherwise identical conditions and equivalent traffic.

Table 4C-2. Minimum Number of Reported Crashes in a One-Year Period

Number of through lanes on each approach		Total of angle and pedestrian crashes (all severities)[a]		Total of fatal-and-injury angle and pedestrian crashes[a]	
Major Street	Minor Street	Four Legs	Three Legs	Four Legs	Three Legs
1	1	5	4	3	3
2 or more	1	5	4	3	3
2 or more	2 or more	5	4	3	3
1	2 or more	5	4	3	3

[a] Angle crashes include all crashes that occur at an angle and involve one or more vehicles on the major street and one or more vehicles on the minor street

Table 4C-3. Minimum Number of Reported Crashes in a Three-Year Period

Number of through lanes on each approach		Total of angle and pedestrian crashes (all severities)[a]		Total of fatal-and-injury angle and pedestrian crashes[a]	
Major Street	Minor Street	Four Legs	Three Legs	Four Legs	Three Legs
1	1	6	5	4	4
2 or more	1	6	5	4	4
2 or more	2 or more	6	5	4	4
1	2 or more	6	5	4	4

[a] Angle crashes include all crashes that occur at an angle and involve one or more vehicles on the major street and one or more vehicles on the minor street

Table 4C-4. Minimum Number of Reported Crashes in a One-Year Period

Community less than 10,000 population or above 40 mph on major street					
Number of through lanes on each approach		Total of angle and pedestrian crashes (all severities)[a]		Total of fatal-and-injury angle and pedestrian crashes[a]	
Major Street	Minor Street	Four Legs	Three Legs	Four Legs	Three Legs
1	1	4	3	3	3
2 or more	1	10	9	6	6
2 or more	2 or more	10	9	6	6
1	2 or more	4	3	3	3

[a] Angle crashes include all crashes that occur at an angle and involve one or more vehicles on the major street and one or more vehicles on the minor street

Table 4C-5. Minimum Number of Reported Crashes in a Three-Year Period

Community less than 10,000 population or above 40 mph on major street					
Number of through lanes on each approach		Total of angle and pedestrian crashes (all severities)[a]		Total of fatal-and-injury angle and pedestrian crashes[a]	
Major Street	Minor Street	Four Legs	Three Legs	Four Legs	Three Legs
1	1	6	5	4	4
2 or more	1	16	13	9	9
2 or more	2 or more	16	13	9	9
1	2 or more	6	5	4	4

[a] Angle crashes include all crashes that occur at an angle and involve one or more vehicles on the major street and one or more vehicles on the minor street

Section 4C.09 Warrant 8, Roadway Network

Support:

01 Installing a traffic control signal at some intersections might be justified to encourage concentration and organization of traffic flow on a roadway network.

Guidance:

02 *The need for a traffic control signal should be considered if an engineering study finds that the common intersection of two or more major routes meets one or both of the following criteria:*

- *A. The intersection has a total existing, or immediately projected, entering volume of at least 1,000 vehicles per hour during the peak hour of a typical weekday and has 5-year projected traffic volumes, based on an engineering study, that meet one or more of Warrants 1, 2, and 3 during an average weekday; or*
- *B. The intersection has a total existing or immediately projected entering volume of at least 1,000 vehicles per hour for each of any 5 hours of a non-normal business day (Saturday or Sunday).*

03 *A major route as used in this signal warrant should have at least one of the following characteristics:*

- *A. It is part of the street or highway system that serves as the principal roadway network for through traffic flow;*
- *B. It includes rural or suburban highways outside, entering, or traversing a city;*
- *C. It appears as a major route on an official plan, such as a major street plan in an urban area traffic and transportation study;*
- *D. It connects areas of principal traffic generation; or*
- *E. It has surface street freeway or expressway ramp terminals.*

Section 4C.10 Warrant 9, Intersection Near a Grade Crossing

Support:

01 The Intersection Near a Grade Crossing signal warrant is intended for use at a location where none of the conditions described in the other eight traffic signal warrants are met, but the proximity of a grade crossing on an approach controlled by a STOP or YIELD sign at a highway-highway intersection is the principal reason to consider installing a traffic control signal.

Guidance:

02 *This signal warrant should be applied only after adequate consideration has been given to other alternatives or after a trial of an alternative has failed to alleviate the safety concerns associated with the grade crossing. Among the alternatives that should be considered or tried are:*

- *A. Providing additional pavement that would enable vehicles to clear the track or that would provide space for an evasive maneuver, or*
- *B. Reassigning the stop controls at the highway-highway intersection to make the approach across the track a non-stopping approach.*

03 *The need for a traffic control signal should be considered if an engineering study finds that both of the following criteria are met:*

- *A. A grade crossing exists on an approach controlled by a STOP or YIELD sign at a highway-highway intersection and the center of the track nearest to the intersection is within 140 feet of the stop line or yield line on the approach; and*
- *B. During the highest traffic volume hour during which rail traffic uses the crossing, the plotted point representing the vehicles per hour on the major street (total of both approaches) of the highway-highway intersection and the corresponding vehicles per hour on the minor-street approach that crosses the track (one direction only, approaching the intersection) falls above the applicable curve in Figure 4C-9 or 4C-10 for the existing combination of approach lanes over the track and the distance D, which is the clear storage distance as defined in Section 1C.02.*

04 *The following considerations apply when plotting the traffic volume data on Figure 4C-9 or 4C-10:*

- *A. Figure 4C-9 should be used if there is only one lane approaching the highway-highway intersection at the track crossing location and Figure 4C-10 should be used if there are two or more lanes approaching the highway-highway intersection at the track crossing location.*
- *B. After determining the actual distance D, the curve for the distance D that is nearest to the actual distance D should be used. For example, if the actual distance D is 95 feet, the plotted point should be compared to the curve for D=90 feet.*
- *C. If the rail traffic arrival times are unknown, the highest traffic volume hour of the day should be used.*

Option:

05 The traffic volume on the minor-street approach to the highway-highway intersection may be multiplied by up to three adjustment factors as provided in Paragraphs 6 through 8 of this Section.

06 Because the curves are based on an average of four occurrences of rail traffic per day, the vehicles per hour on the minor-street approach may be multiplied by the adjustment factor shown in Table 4C-6 for the appropriate number of occurrences of rail traffic per day.

07 Because the curves are based on typical vehicle occupancy, if at least 2% of the vehicles crossing the track are buses carrying at least 20 people, the vehicles per hour on the minor-street approach may be multiplied by the adjustment factor shown in Table 4C-7 for the appropriate percentage of high-occupancy buses.

08 Because the curves are based on tractor-trailer trucks comprising 10% of the vehicles crossing the track, the vehicles per hour on the minor-street approach may be multiplied by the adjustment factor shown in Table 4C-8 for the appropriate distance and percentage of tractor-trailer trucks.

Table 4C-6. Warrant 9, Adjustment Factor for Daily Frequency of Rail Traffic

Rail traffic per day	Adjustment factor
2	0.91
6 to 8	1.18
12 or more	1.33

Table 4C-7. Warrant 9, Adjustment Factor for Percentage of High-Occupancy Buses

% of high-occupancy buses* on minor-street approach	Adjustment factor
2%	1.09
6% or more	1.32

*** A high-occupancy bus is defined as a bus occupied by at least 20 people.**

Standard:

09 **If this warrant is met and a traffic control signal at the highway-highway intersection is justified by an engineering study, then:**

A. The traffic control signal shall have actuation on the minor street,

B. Preemption control shall be provided in accordance with Sections 4F.19 and 8D.09, and

C. The grade crossing shall have flashing-light signals (see Section 8D.02).

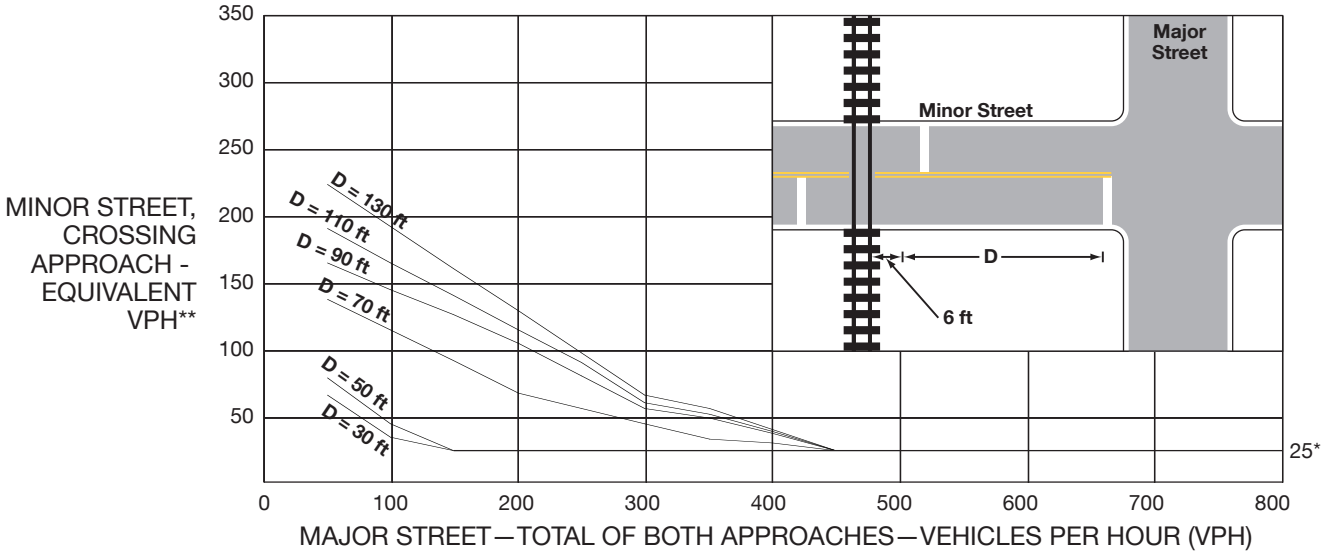
Guidance:

10 *If this warrant is met and a traffic control signal at the highway-highway intersection is justified by an engineering study, the grade crossing should have automatic gates (see Section 8D.03).*

Table 4C-8. Warrant 9, Adjustment Factor for Percentage of Tractor-Trailer Trucks

% of tractor-trailer trucks on minor-street approach	Adjustment factor	
	D less than 70 feet	D of 70 feet or more
0% to 2.5%	0.50	0.50
2.6% to 7.5%	0.75	0.75
7.6% to 12.5%	1.00	1.00
12.6% to 17.5%	2.30	1.15
17.6% to 22.5%	2.70	1.35
22.6% to 27.5%	3.28	1.64
More than 27.5%	4.18	2.09

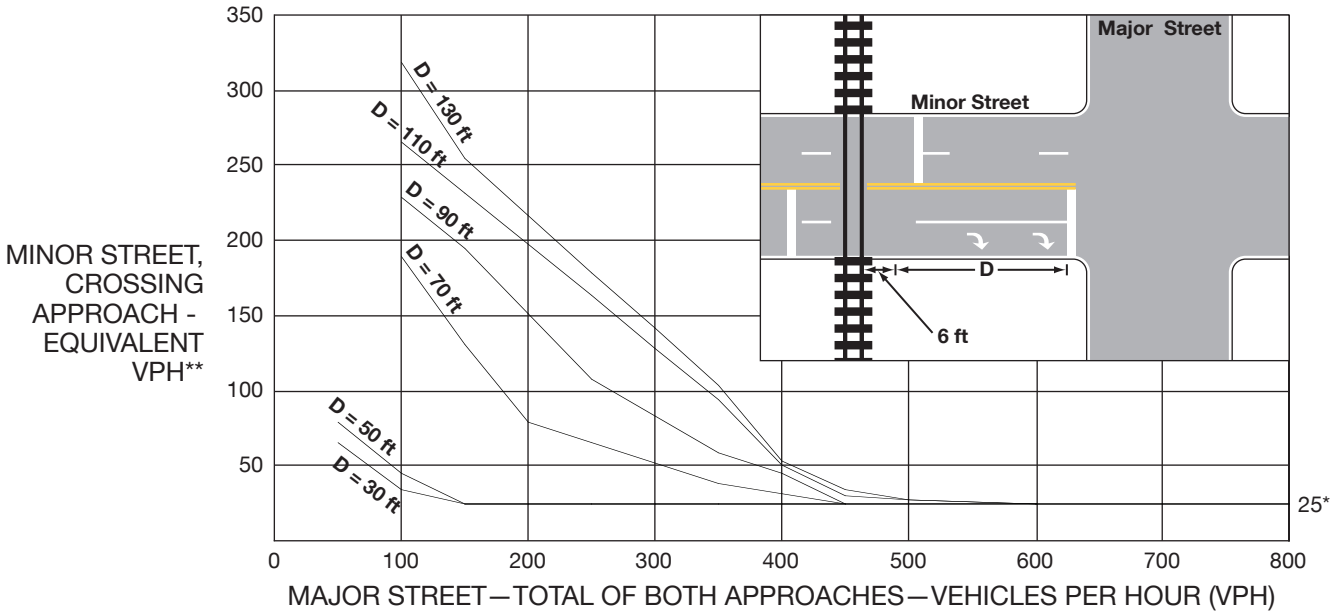
Figure 4C-9. Warrant 9, Intersection Near a Grade Crossing (One Approach Lane at the Track Crossing)



* 25 vph applies as the lower threshold volume

** VPH after applying the adjustment factors in Tables 4C-6, 4C-7, and/or 4C-8, if appropriate

Figure 4C-10. Warrant 9, Intersection Near a Grade Crossing (Two or More Approach Lanes at the Track Crossing)



* 25 vph applies as the lower threshold volume

** VPH after applying the adjustment factors in Tables 4C-6, 4C-7, and/or 4C-8, if appropriate

CHAPTER 4D. DESIGN FEATURES OF TRAFFIC CONTROL SIGNALS

Section 4D.01 General

Support:

01 The features of traffic control signals of interest to road users are the location, design, and meaning of the signal indications. Uniformity in the design features that affect the traffic to be controlled, as set forth in this Manual, is especially important for the safety and efficiency of operations.

02 Traffic control signals can be operated in pretimed, semi-actuated, or full-actuated modes. For isolated (non-interconnected) signalized locations on rural high-speed highways, full-actuated mode with advance vehicle detection on the high-speed approaches is typically used. These features are designed to reduce the frequency with which the onset of the yellow change interval is displayed when high-speed approaching vehicles are in the "dilemma zone" such that the drivers of these high-speed vehicles find it difficult to decide whether to stop or proceed.

Standard:

03 **The design and operation of traffic control signals shall take into consideration the needs of all modes of traffic including access and safety.**

04 **When a traffic control signal is not in operation, such as before it is placed in service, during seasonal shutdowns, or when it is not desirable to operate the traffic control signal, the signal faces shall be covered, turned, or taken down to clearly indicate that the traffic control signal is not in operation.**

Guidance:

05 *If a cover is placed over a traffic control signal face that is not in operation and that has a yellow retroreflective strip along the perimeter of its signal backplate (see Paragraph 21 in Section 4D.06), the entire signal face, including the backplate, should be covered. If a traffic control signal face that is not in operation and that has a yellow retroreflective strip along the perimeter of its signal backplate is turned, the turned signal face should be oriented such that the yellow backplate border will not reflect light back to road users on any of the approaches to the intersection.*

Support:

06 Seasonal shutdown is a condition in which a permanent traffic control signal is turned off or otherwise made non-operational during a particular season when its operation is not justified. This might be applied in a community where tourist traffic during most of the year justifies the permanent signalization, but a seasonal shutdown of the signal during an annual period of lower tourist traffic would reduce delays; or where a major traffic generator, such as a large factory, justifies the permanent signalization, but the large factory is shut down for an annual factory vacation for a few weeks in the summer.

Standard:

07 **A traffic control signal shall control traffic only at the intersection or midblock location where the signal faces are placed.**

Guidance:

08 *Midblock crosswalks should not be signalized if they are located within 300 feet from the nearest traffic control signal, unless supported by an engineering study or engineering judgment that indicates safe and efficient operation of the closely-spaced traffic control signals can be achieved.*

09 *Midblock crosswalks should not be signalized if they are located within 100 feet from side streets or driveways that are controlled by STOP signs or YIELD signs, unless supported by an engineering study or engineering judgment that considers restricting turning movements from the side street or driveway to eliminate conflicts with pedestrian and bicyclist movements.*

10 *Engineering judgment should be used to determine the proper phasing and timing for a traffic control signal. Since traffic flows and patterns change, phasing and timing should be reevaluated regularly and updated if needed.*

11 *Traffic control signals within ½ mile of one another along a major route or in a network of intersecting major routes should be coordinated, preferably with interconnected controller units. Where traffic control signals that are within ½ mile of one another along a major route have a jurisdictional boundary or a boundary between different signal systems between them, coordination across the boundary should be considered.*

Support:

12 Signal coordination need not be maintained between control sections that operate on different cycle lengths.

13 Sections 4F.19, 4Q.03, and 8D.09 contain information about coordination of traffic control signals with grade crossing signals and movable bridge signals.

Section 4D.02 Provisions for Pedestrians

Support:

01 Chapter 4I contains additional information regarding pedestrian control features, Chapter 4J contains additional information regarding pedestrian hybrid beacons, and Chapter 4K contains additional information regarding accessible pedestrian signals and detectors.

Standard:

02 **Pedestrian signal heads shall be used in conjunction with vehicular traffic control signals under any of the following conditions, unless the pedestrian crossing is prohibited:**

- **A. If the basis for traffic signal installation was justified by an engineering study and meeting either Warrant 4, Pedestrian Volume or Warrant 5, School Crossing (see Chapter 4C);**
- **B. If an exclusive pedestrian signal phase or a leading pedestrian interval (LPI) is provided with all conflicting vehicular movements being stopped;**
- **C. At an established signalized school crossing; or**
- **D. Where there are existing pedestrian accommodations and engineering judgment determines that multi-phase signal indications (such as split-phase timing) would tend to confuse or cause conflicts with pedestrians using a crosswalk guided only by vehicular signal indications.**

Guidance:

03 *Pedestrian signal heads should be installed for each marked crosswalk at a location controlled by a traffic control signal.*

04 *Where pedestrian movements regularly occur, pedestrians should be provided with sufficient time to cross the roadway by adjusting the traffic control signal operation and timing to provide sufficient crossing time every cycle or by providing pedestrian detectors.*

05 *Where certain pedestrian movements are prohibited at a traffic control signal location, a No Pedestrian Crossing (R9-3) sign (see Section 2B.57) should be used if it is impracticable to provide a barrier or other physical feature to physically discourage the pedestrian movements.*

Support:

06 Accessible pedestrian signals (see Chapter 4K) that provide information in non-visual formats (such as audible tones and/or speech messages, and vibrating surfaces) enhance safety and accessibility at signalized crossings for pedestrians with vision disabilities.

Option:

07 Pedestrian signal heads may be used under other conditions based on engineering judgment.

Section 4D.03 Provisions for Bicyclists

Standard:

01 **At installations where visibility-limited signal faces are used, signal faces shall be adjusted so bicyclists for whom the indications are intended can see the signal indications. If the visibility-limited signal faces cannot be aimed to serve the bicyclist, then separate signal faces (see Chapter 4H) shall be provided for the bicyclist.**

02 **On bikeways, signal timing and actuation shall be reviewed and adjusted to consider the needs of bicyclists.**

Option:

03 Where it is desired to provide separate signal indications to control bicyclist movements at a traffic control signal, bicycle signal faces may be used (see Chapter 4H).

Support:

04 Sections 9B.02, 9B.11, 9B.20, 9B.22, 9E.02, 9E.06, 9E.07, 9E.08, 9E.11, 9E.12, and 9E.15 contain additional provisions regarding bicyclist movements and actuation at traffic control signals.

Section 4D.04 Provisions for Transit Vehicles

Option:

01 Where it is desired to provide separate signal indications to control transit vehicles at a traffic control signal, LRT signal indications may be used at intersections where special signal phases are used for transit vehicles (see Section 8D.15).

Section 4D.05 Number of Signal Faces on an Approach

Standard:

01 **The signal faces for each approach to an intersection or a midblock location shall be provided as follows:**

Rev. 1

- **A. If a signalized motor vehicle through movement exists on an approach, a minimum of two primary signal faces shall be provided for the through movement. Except for single lane approaches with a combined left-turn/right-turn lane and no through movement (see Figure 4F-15 (A)), if a signalized motor vehicle through movement does not exist on an approach, a minimum of two primary signal faces shall be provided for the signalized motor vehicle turning movement that is considered to be the major movement from the approach (also see Section 4F.16).**
- **B. See Sections 4F.02 through 4F.08 for left-turn (and U-turn to the left) signal faces.**
- **C. See Sections 4F.09 through 4F.15 for right-turn (and U-turn to the right) signal faces.**

Option:

02 Where a movement (or a certain lane or lanes) at the intersection never conflicts with any other signalized vehicular or pedestrian movement, a continuously-displayed single-section GREEN ARROW signal indication may be used to inform road users that the movement is free-flow and does not need to stop.

Support:

03 In some circumstances where the through movement never conflicts with any other signalized vehicular or pedestrian movement at the intersection, such as at T-intersections with appropriate geometrics and/or pavement markings and signing, an engineering study might determine that the through movement (or certain lanes of the through movement) can be free-flow and not signalized.

Guidance:

04 *If two or more left-turn lanes are provided for a separately-controlled left-turn movement, or if a left-turn movement represents the major movement from an approach, two or more primary left-turn signal faces should be provided.*

05 *If two or more right-turn lanes are provided for a separately-controlled right-turn movement, or if a right-turn movement represents the major movement from an approach, two or more primary right-turn signal faces should be provided.*

Support:

06 Locating primary signal faces overhead on the far side of the intersection has been shown to provide safer operation by reducing intersection entries late in the yellow interval and by reducing red signal violations, as compared to post-mounting signal faces at the roadside or locating signal faces overhead within the intersection on a diagonally-oriented mast arm or span wire. On approaches with two or more lanes for the through movement, one signal face per through lane, centered over each through lane, has also been shown to provide safer operation.

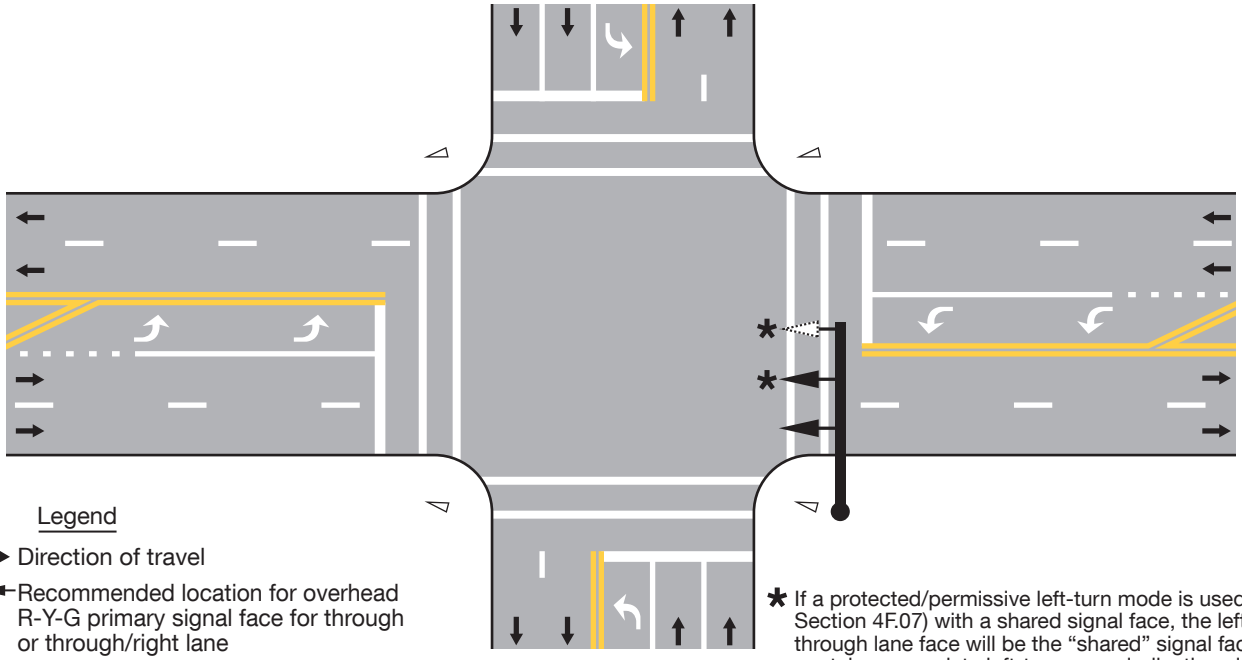
Guidance:

07 *If the posted or statutory speed limit or the 85th-percentile speed on an approach to a signalized location is 45 mph or higher, signal faces should be provided as follows for all new or reconstructed signal installations (see Figure 4D-1):*

- *A. The minimum number and location of primary (non-supplemental) signal faces for through traffic should be provided in accordance with Table 4D-1.*
- *B. If the number of overhead primary signal faces for through traffic is equal to the number of through lanes on an approach, one overhead signal face should be located approximately over the center of each through lane.*
- *C. Except for shared left-turn and right-turn signal faces, any primary signal face required by Sections 4F.02 through 4F.16 for a mandatory turn lane should be located overhead approximately over the center of each mandatory turn lane.*
- *D. All primary signal faces should be located on the far side of the intersection.*
- *E. In addition to the primary signal faces, one or more supplemental pole-mounted or overhead signal faces should be considered to provide added visibility for approaching traffic that is traveling behind large vehicles.*
- *F. All signal faces should have backplates.*

08 *This layout of signal faces should also be considered for any major urban or suburban arterial street with four or more lanes and for other approaches with speeds of less than 45 mph.*

Figure 4D-1. Recommended Vehicular Signal Faces for Approaches with Posted, Statutory, or 85th-Percentile Speed of 45 mph or Higher



Legend

- Direction of travel
- Recommended location for overhead R-Y-G primary signal face for through or through/right lane
- Overhead primary left-turn signal face as determined by selected mode of left-turn operation
- Possible location for a supplemental R-Y-G signal face

* If a protected/permissive left-turn mode is used (see Section 4F.07) with a shared signal face, the left-most through lane face will be the "shared" signal face, will contain appropriate left-turn arrow indications in addition to circular R-Y-G, and typicallywill be located over the projection of the lane line between the left-turn and through lanes.

Notes:

1. Signal faces for only one direction and only one possible set of geometrics (number of lanes, etc.) are illustrated. If there are fewer or more than two through lanes on the approach, see Table 4D-1.
2. Any primary left-turn and/or right-turn signal faces, as determined by Sections 4F.02 through 4F.15, should be overhead for each mandatory turn lane.
3. One or more pole-mounted or overhead supplemental faces should be considered, based on the geometrics of the approach, to maximize visibility for approaching traffic.
4. All signal faces should have backplates.

Table 4D-1. Recommended Minimum Number of Primary Signal Faces for Through Traffic on Approaches with Posted, Statutory, or 85th-Percentile Speed of 45 mph or Higher

Number of Through Lanes on the Approach	Total Number of Primary Through Signal Faces for the Approach*	Minimum Number of Overhead-Mounted Primary Through Signal Faces for the Approach
1	2	1
2	2	1
3	3	2**
4 or more	4 or more	3**

Notes:

*** A minimum of two through signal faces is always required (see Section 4D.05). These recommended numbers of through signal faces may be exceeded. Also, see cone of vision requirements otherwise indicated in Section 4D.07.**

**** If practical, all of the recommended number of primary through signal faces should be located overhead.**

Section 4D.06 Visibility, Aiming, and Shielding of Signal Faces

Guidance:

01 *The visibility of signal indications to approaching traffic should be the highest priority for signal face placement and aiming.*

02 *Road users approaching a signalized intersection or other signalized area, such as a midblock crosswalk, should be given a clear and unmistakable indication of whether they are being directed to stop or permitted to proceed.*

03 *The geometry of each intersection to be signalized, including vertical grades, horizontal curves, and obstructions as well as the lateral and vertical angles of sight toward a signal face, as determined by typical driver-eye position, should be considered in determining the vertical, longitudinal, and lateral position of the signal face.*

04 *At signalized midblock crosswalks, at least one of the signal faces should be over the traveled way for each approach.*

05 *The two primary signal faces required as a minimum for each approach should be continuously visible to traffic approaching the traffic control signal, from a point at least the minimum sight distance provided in Table 4D-2 in advance of and measured to the stop line. This range of continuous visibility should be provided unless precluded by a physical obstruction or unless another signalized location is within this range.*

06 *If approaching traffic does not have a continuous view of at least two signal faces for at least the minimum sight distance shown in Table 4D-2, a sign (see Section 2C.35) should be installed to warn approaching traffic of the traffic control signal.*

Table 4D-2. Minimum Sight Distance for Signal Visibility

85th-Percentile Speed	Minimum Sight Distance
20 mph	175 feet
25 mph	215 feet
30 mph	270 feet
35 mph	325 feet
40 mph	390 feet
45 mph	460 feet
50 mph	540 feet
55 mph	625 feet
60 mph	715 feet

Note: Distances in this table are derived from stopping sight distance plus an assumed queue length for shorter cycle lengths (60 to 75 seconds).

Option:

07 If a sign is installed to warn approaching road users of the traffic control signal, the sign may be supplemented by a Warning Beacon (see Section 4S.03).

08 A Warning Beacon used in this manner may be interconnected with the traffic signal controller assembly in such a manner as to flash yellow during the period when road users passing this beacon at the legal speed for the roadway might encounter a red signal indication (or a queue resulting from the display of the red signal indication) upon arrival at the signalized location.

09 If the sight distance to the signal faces for an approach is limited by horizontal or vertical alignment, supplemental signal faces aimed at a point on the approach at which the signal indications first become visible may be used.

Guidance:

10 *Supplemental signal faces should be used if engineering judgment has shown that they are needed to achieve intersection visibility both in advance and immediately before the signalized location.*

11 *If supplemental signal faces are used, they should be located to provide optimum visibility for the movement to be controlled.*

12 *In cases where irregular street design necessitates placing signal faces for different street approaches with a comparatively small angle between their respective signal indications, each signal indication should, to the extent practical, be visibility-limited by signal visors, signal louvers, or other means so that an approaching road user's view of the signal indication(s) controlling movements on other approaches is minimized.*

Standard:

13 **Signal visors exceeding 12 inches in length shall not be used on free-swinging signal faces.**

Guidance:

14 *Signal visors should be used on signal faces to aid in directing the signal indication specifically to approaching traffic, as well as to reduce "sun phantom," which can result when external light enters the lens.*

15 *The use of signal visors, or the use of signal faces or devices that direct the light without a reduction in intensity, should be considered as an alternative to signal louvers because of the reduction in light output caused by signal louvers.*

Option:

16 Special signal faces, such as visibility-limited signal faces, may be used such that the road user does not see signal indications intended for other approaches before seeing the signal indications for their own approach, especially if simultaneous viewing of both signal indications could cause the road user to be misdirected.

Guidance:

17 *If the posted or statutory speed limit or the 85th-percentile speed on an approach to a signalized location is 45 mph or higher, signal backplates should be used on all of the signal faces that face the approach. Signal backplates should also be considered for use on signal faces on approaches with posted or statutory speed limits or 85th-percentile speeds of less than 45 mph where sun glare, bright sky, and/or complex or confusing backgrounds indicate a need for enhanced signal face target value.*

Support:

18 The use of backplates enhances the contrast between the traffic signal indications and their surroundings for both day and night conditions, which is also helpful to older drivers.

Standard:

19 **If backplates are used, ancillary legends of any kind that identify the purpose or operation of the signal face shall not be placed on the backplate.**

20 **The inside of signal visors (hoods), the entire surface of louvers and fins, and the front surface of backplates shall have a dull black finish to minimize light reflection and to increase contrast between the signal indication and its background.**

Option:

21 A yellow retroreflective strip with a minimum width of 1 inch and a maximum width of 3 inches may be placed along the perimeter of the face of a signal backplate to project a rectangular appearance at night.

Section 4D.07 Lateral Positioning of Signal Faces

Standard:

01 **At least one and preferably both of the minimum of two primary signal faces required for the through movement (or the major turning movement if there is no through movement) on the approach shall be located between two lines intersecting with the center of the approach at a point 10 feet behind the stop line, one making an angle of approximately 20 degrees to the right of the center of the approach extended, and the other making an angle of approximately 20 degrees to the left of the center of the approach extended. The signal face that satisfies this requirement shall simultaneously satisfy the longitudinal placement requirement described in Section 4D.08 (see Figure 4D-2).**

02 **If both of the minimum of two primary signal faces required for the through movement (or the major turning movement if there is no through movement) on the approach are post-mounted, they shall both be on the far side of the intersection, one on the right and one on the left of the approach lane(s).**

03 **The required signal faces for through traffic on an approach shall be located not less than 8 feet apart measured horizontally perpendicular to the approach between the centers of the signal faces.**

04 **If more than one separate turn signal face is provided for a turning movement and if one or both of the separate turn signal faces are located over the roadway, the signal faces shall be located not less than 8 feet apart measured horizontally perpendicular to the approach between the centers of the signal faces.**

Guidance:

05 *If horizontally-arranged or clustered signal faces are used, the minimum 8-foot horizontal separation between the two signal faces should be measured from the center of the right-most signal indication in the signal face on the left to the center of the left-most signal indication in the signal face on the right.*

06 *Except as provided in Paragraph 7 of this Section, for signal faces located over the roadway, separate turn signal faces should be located at least 8 feet from the nearest traffic signal face for a different movement on the same approach measured horizontally perpendicular to the approach between the centers of the signal faces.*

Option:

07 For modifications to existing traffic signals, the minimum horizontal separation between a separate turn signal face and the nearest traffic signal face for a different movement may be reduced to 3 feet.

Guidance:

08 *If a signal face controls a specific lane or lanes of an approach, its position should make it readily visible to road users making that movement.*

Support:

09 Section 4D.05 contains additional provisions regarding lateral positioning of signal faces for approaches having a posted or statutory speed limit or an 85th-percentile speed of 45 mph or higher.

Guidance:

10 *If a mandatory left-turn, right-turn, or U-turn lane is present on an approach and if a primary separate turn signal face controlling that lane is mounted over the roadway, the primary separate turn signal face should not be positioned any farther to the right than the extension of the right-hand edge of the mandatory turn lane or any farther to the left than the extension of the left-hand edge of the mandatory turn lane.*

Support:

11 Supplemental turn signal faces mounted over the roadway are not subject to the positioning recommendations in Paragraph 10 of this Section.

Guidance:

12 *For new or reconstructed signal installations, on an approach with a mandatory turn lane(s) for a permissive left-turn (or U-turn to the left) movement, signal faces that display a CIRCULAR GREEN signal indication should not be post-mounted on the far-side median or mounted overhead above the mandatory turn lane(s) or the extension of the lane(s).*

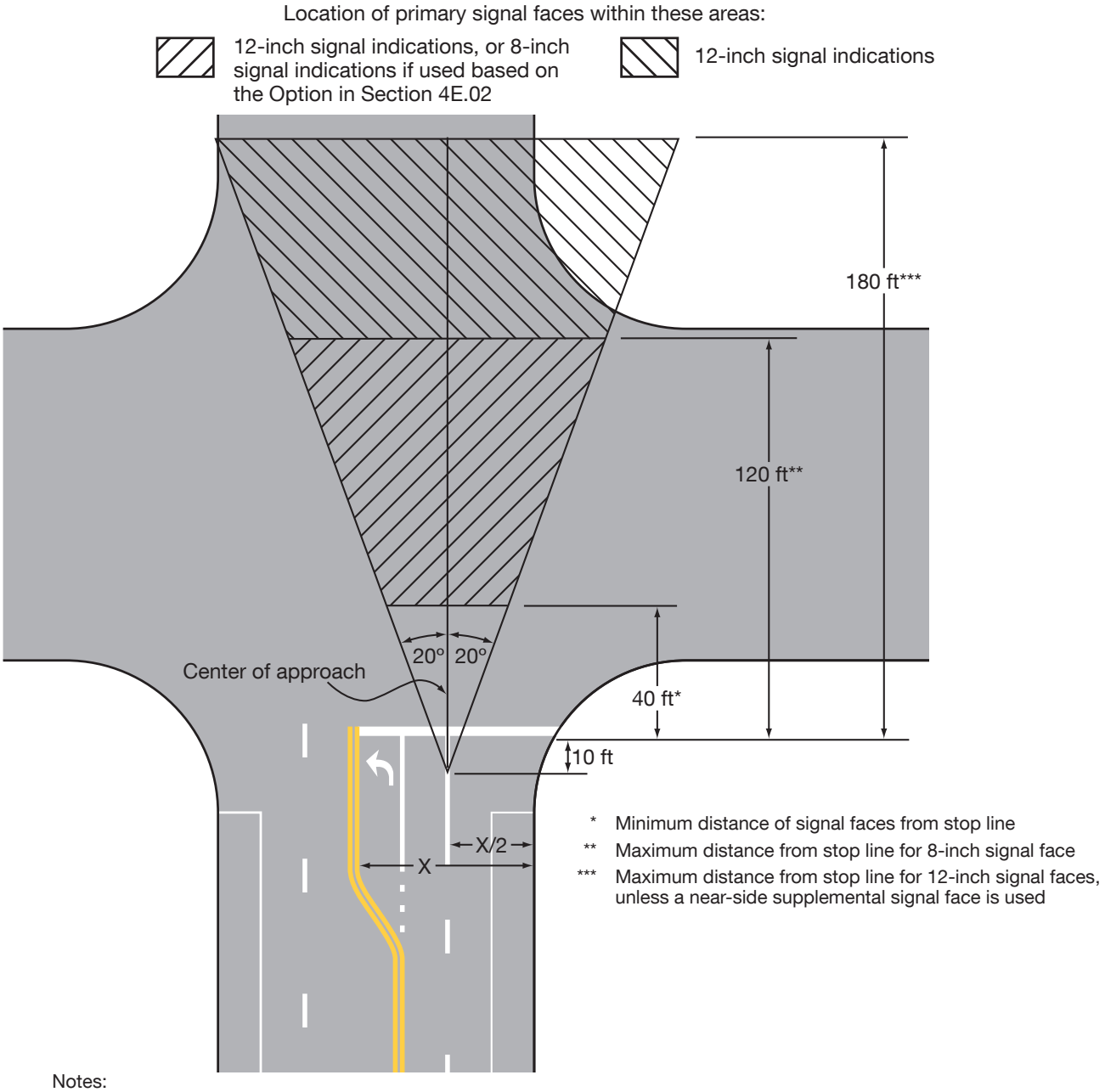
Standard:

13 **If supplemental post-mounted signal faces are used, the following limitations shall apply:**

A. Left-turn arrows and U-turn arrows to the left shall not be used in near right signal faces that are located to the right of the through and/or right-turn lanes.

B. Right-turn arrows and U-turn arrows to the right shall not be used in far left signal faces that are located to the left of the through and/or left-turn lanes. A far-side median-mounted signal face shall be considered a far left signal face for this application.

Figure 4D-2. Lateral and Longitudinal Location of Primary Signal Faces



Notes:

1. See Section 4D.05 for approaches with posted, statutory, or 85th-percentile speeds of 45 mph or higher
2. See Section 4D.07 regarding location of signal faces that display a CIRCULAR GREEN signal indication for a permissive left-turn movement on approaches with a mandatory left-turn lane or lanes

Section 4D.08 Longitudinal Positioning of Signal Faces

Standard:

01 **Except where the width of an intersecting roadway or other conditions make it physically impractical, the signal faces for each approach to an intersection or a midblock location shall be provided as follows:**

- **A. A signal face installed to satisfy the requirements for primary left-turn signal faces (see Sections 4F.02 through 4F.08) and primary right-turn signal faces (see Sections 4F.09 through 4F.15), and at least one and preferably both of the minimum of two primary signal faces required for the through movement (or the major turning movement if there is no through movement) on the approach shall be located:**
  - **1. No less than 40 feet beyond the stop line, and**
  - **2. No more than 180 feet beyond the stop line unless a supplemental near-side signal face is provided.**
- **B. The primary signal faces that are used to satisfy the requirements of Item A shall simultaneously satisfy the lateral placement requirement described in Section 4D.07 (see Figure 4D-2).**

Guidance:

02 *Where the nearest signal face is located between 150 and 180 feet beyond the stop line, engineering judgment of the conditions, including the worst-case visibility conditions, should be used to determine if the provision of a supplemental near-side signal face would be beneficial.*

03 *Supplemental near-side signal faces should be located as near as practicable to the stop line.*

Support:

04 Section 4D.05 contains additional provisions regarding longitudinal positioning of signal faces for approaches having a posted or 85th-percentile speed of 45 mph or higher.

Section 4D.09 Mounting Height of Signal Faces

Standard:

01 **The bottom of the signal housing and any related attachments to a vehicular signal face located over any portion of a highway that can be used by motor vehicles shall be at least 15 feet above the pavement.**

02 **The bottom of the signal housing (including brackets) of a vehicular signal face that is vertically arranged or horizontally arranged and not located over a roadway:**

- **A. Shall be a minimum of 8 feet above the sidewalk or, if there is no sidewalk, above the pavement grade at the center of the roadway.**
- **B. Shall be a minimum of 4.5 feet above the median island grade of a center median island if located on the near side of the intersection.**

Guidance:

03 *The top of the signal housing of a vehicular signal face located over any portion of a highway that can be used by motor vehicles should not be more than 25.6 feet above the pavement.*

04 *For viewing distances between 40 and 53 feet from the stop line, the maximum mounting height to the top of the signal housing of a vehicular signal face located over any portion of a highway that can be used by motor vehicles should be as shown in Figure 4D-3.*

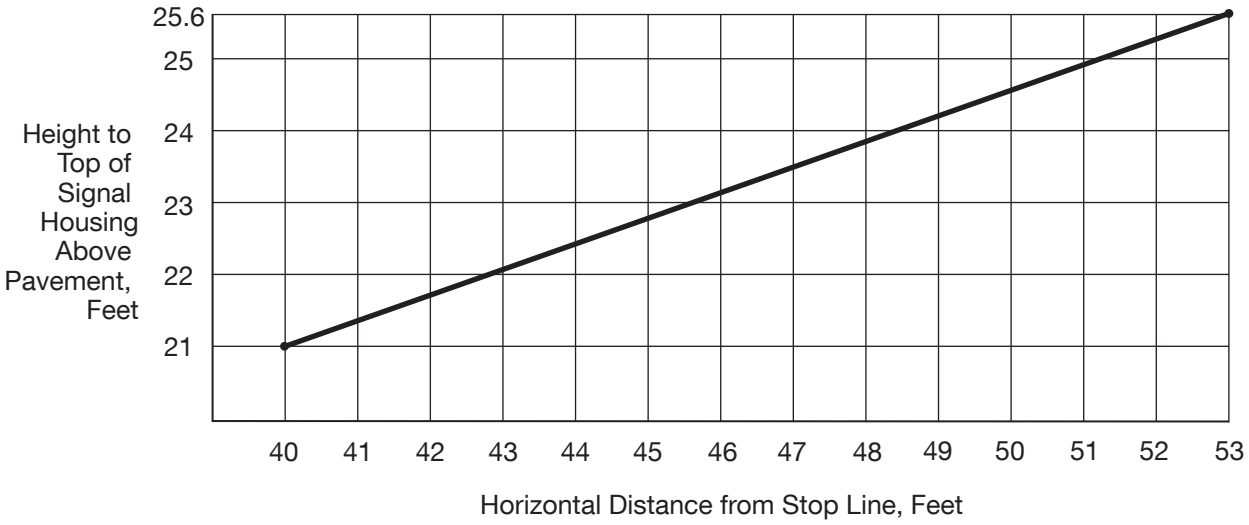
05 *The bottom of the signal housing (including brackets) of a vehicular signal face that is vertically arranged and not located over a roadway or shoulder:*

- *A. Should be a maximum of 19 feet above the sidewalk or, if there is no sidewalk, above the pavement grade at the center of the roadway.*
- *B. Should be a maximum of 19 feet above the median island grade of a center median island if located on the near side of the intersection.*

06 *The bottom of the signal housing (including brackets) of a vehicular signal face that is horizontally arranged and not located over a roadway or shoulder:*

- *A. Should be a maximum of 22 feet above the sidewalk or, if there is no sidewalk, above the pavement grade at the center of the roadway.*
- *B. Should be a maximum of 22 feet above the median island grade of a center median island if located on the near side of the intersection.*

Figure 4D-3. Maximum Mounting Height of Signal Faces that Are Located between 40 Feet and 53 Feet from the Stop Line



Section 4D.10 Lateral Offset (Clearance) of Signal Faces

Guidance:

01 *Signal faces mounted at the side of a roadway at less than 15 feet from the bottom of the housing and any related attachments should have a horizontal offset of not less than 2 feet from the face of a vertical curb, or if there is no curb, not less than 2 feet from the edge of a shoulder.*

Section 4D.11 Temporary and Portable Traffic Control Signals

Support:

01 A temporary traffic control signal is generally installed using methods that minimize the costs of installation, relocation, and/or removal. Typical temporary traffic control signals are for specific purposes, such as for one-lane, two-way facilities in temporary traffic control zones (see Chapter 4O), for a haul-road intersection, or for access to a site that will have a permanent access point developed at another location in the near future. Portable traffic signals are temporary traffic signals.

02 Because a portable traffic control signal is considered to be a type of temporary traffic control signal, the provisions for temporary traffic control signals are also applicable to portable traffic control signals. Rev. 1

Standard:

03 **Advance signing shall be used when employing a temporary traffic control signal.**

04 **A temporary traffic control signal shall:**

- **A. Meet the physical display and operational requirements of a conventional traffic control signal;**
- **B. Be removed when no longer needed; and**
- **C. Except as provided in Paragraph 5 of this Section, be placed in the flashing mode during periods when it is not desirable to operate the signal in the steady mode, or the signal heads shall be covered, turned, or taken down to indicate that the signal is not in operation.**

Option:

05 If the temporary traffic control signal is capable of being operated in a semi-actuated mode, such that green signal indications are continually shown to major-street traffic except when responding to a minor-street approach vehicle call, it may be operated in a semi-actuated mode instead of being placed in a flashing mode.

Guidance:

06 *A temporary traffic control signal should be used only if engineering judgment indicates that installing the signal will improve the overall safety and/or operation of the location.*

07 *The use of temporary traffic control signals by a work crew on a regular basis in their work area should be subject to the approval of the jurisdiction having authority over the roadway.*

08 *A temporary traffic control signal should not operate longer than 30 days unless associated with a longer-term temporary traffic control zone project.*

Support:

09 Section 6L.01 contains information about the use of temporary traffic control signals in temporary traffic control zones.

CHAPTER 4E. TRAFFIC CONTROL SIGNAL INDICATIONS

Section 4E.01 Signal Indications – Design, Illumination, Color, and Shape

Standard:

01 **The illuminated part of each signal indication shall be circular or arrow, except those used for bicycle symbol signal indications, pedestrian signal heads, light rail transit signal indications, and lane-use control signals.**

02 **Letters or numbers (including those associated with countdown displays) shall not be displayed as part of a vehicular signal indication.**

03 **Strobes shall not be used within or adjacent to any signal indication.**

04 **Except for the flashing vehicular and pedestrian signal indications and the distinctive indications for emergency-vehicle preemption (see Section 4F.19) that are expressly allowed by the provisions of this Part, flashing displays shall not be used within or adjacent to any signal indications.**

05 **Each circular signal indication shall emit a single color: red, yellow, or green.**

06 **Except as provided in Paragraph 7 of this Section, each arrow signal indication shall emit a single color: red, yellow, or green.**

Option:

07 A bimodal signal section that is capable of alternating between the display of a GREEN ARROW signal indication and the display of a YELLOW ARROW signal indication, both pointing in the same direction, may be used provided that both colors are never displayed simultaneously.

Standard:

08 **The arrow, which shall show only one direction, shall be the only illuminated part of an arrow signal indication.**

09 **Arrows shall be pointed:**

- **A. Vertically upward to indicate a straight-through movement,**
- **B. Horizontally in the direction of the turn to indicate a turn at approximately or greater than a right angle,**
- **C. Upward with a slope at an angle approximately equal to that of the turn if the angle of the turn is substantially less than a right angle, or**
- **D. In a manner that directs the driver through the turn if a U-turn arrow is used (see Figure 4E-1).**

10 **Except as provided in Paragraph 11 of this Section, the requirements of Chapters 1 and 2 of the publication entitled "Equipment and Materials Standards of the Institute of Transportation Engineers" that pertain to the aspects of the signal head design that affect the display of the signal indications shall be met for signal optical units that use incandescent lamps within optical assemblies that include lenses. Except as provided in Paragraph 11 of this Section, the requirements of the Institute of Transportation Engineers' publications entitled "Vehicle Traffic Control Signal Heads: Light Emitting Diode (LED) Circular Signal Supplement," 2005, ITE, and "Vehicle Traffic Control Signal Heads: Light Emitting Diode (LED) Vehicle Arrow Traffic Signal Supplement," 2008, ITE, that pertain to the aspects of the signal head design that affect the display of the signal indications shall be met for light-emitting diode (LED) traffic signal modules.**

Figure 4E-1. Typical Arrangements of U-Turn Signal Faces



Guidance:

11 *The intensity and distribution of light from each illuminated signal lens or LED signal module should comply with the publications specified in Paragraph 10 of this Section, as appropriate.*

Support:

12 References to signal lenses in this Section are not intended to limit signal optical units to incandescent lamps within optical assemblies that include lenses. Research has resulted in signal optical units that are not lenses, such as, but not limited to, light-emitting diode (LED) traffic signal modules. Some units are practical for all signal indications, and some are practical for specific types such as visibility-limited signal indications.

Rev. 1

Guidance:

13 *If a signal indication is so bright that it causes excessive glare during nighttime conditions, some form of automatic dimming should be used to reduce the brilliance of the signal indication.*

Section 4E.02 Size of Vehicular Signal Indications

Standard:

01 **There shall be three nominal diameter sizes for vehicular signal indications: 4 inches, 8 inches, and 12 inches.**

02 **Four-inch signal indications shall only be used for bicycle signal faces per Section 4H.07.**

03 **Twelve-inch signal indications shall be used for all arrow signal indications.**

04 **Except as provided in Paragraph 5 of this Section, 12-inch signal indications shall be used for all circular signal indications in all new signal faces.**

Option:

05 Eight-inch circular signal indications may be used in new signal faces only for:

A. The green or flashing yellow signal indications in an emergency-vehicle traffic control signal (see Section 4M.02);
B. The circular indications in signal faces controlling the approach to the downstream location where two adjacent signalized locations are close to each other and it is impractical because of factors such as high approach speeds, horizontal or vertical curves, or other geometric factors to install visibility-limited signal faces for the downstream approach;
C. The circular indications in a signal face that is located less than 120 feet from the stop line on a roadway with a posted or statutory speed limit or operating speed of 30 mph or less;
D. The circular indications in a supplemental near-side signal face;
E. The circular indications in a supplemental signal face installed for the sole purpose of controlling pedestrian movements rather than vehicular movements; and
F. The circular indications in a flashing beacon (see Chapter 4S).

06 Different sizes of signal indications may be used in the same signal face or signal head, provided that the signal face or signal head complies with the requirements contained in Paragraphs 3 through 5 of this Section.

Section 4E.03 Positions of Signal Indications within a Signal Face – General

Support:

01 Standardization of the number and arrangements of signal sections in vehicular traffic control signal faces enables road users who are color vision deficient to identify the illuminated color by its position relative to other signal sections.

Standard:

02 **Unless otherwise provided in this Manual for a particular application, each signal face at a signalized location shall have three, four, or five signal sections. Unless otherwise provided in this Manual for a particular application, if a vertical signal face includes a cluster (see Section 4E.04), the signal face shall have at least three vertical positions.**

03 **A single-section signal face shall be permitted at a traffic control signal if it consists of a continuously-displayed GREEN ARROW signal indication that is being used to indicate a continuous movement.**

04 **The signal sections in a signal face shall be arranged in a vertical or horizontal straight line, except as otherwise provided in Section 4E.04.**

05 **The arrangement of adjacent signal sections in a signal face shall follow the relative positions listed in Sections 4E.04 or 4E.05, as applicable.**

06 **If a signal section that displays a CIRCULAR YELLOW signal indication is used, it shall be located between the signal section that displays the red signal indication and all other signal sections.**

07 **If a U-turn arrow signal section is used in a signal face for a U-turn to the left, its position in the signal face shall be the same as stated in Sections 4E.04 and 4E.05 for a left-turn arrow signal section of the same color. If a U-turn arrow signal section is used in a signal face for a U-turn to the right, its position in the signal face shall be the same as stated in Sections 4E.04 and 4E.05 for a right-turn arrow signal section of the same color.**

08 **A U-turn arrow signal indication pointing to the left shall not be used in a signal face that also contains a left-turn arrow signal indication. A U-turn arrow signal indication pointing to the right shall not be used in a signal face that also contains a right-turn arrow signal indication.**

Option:

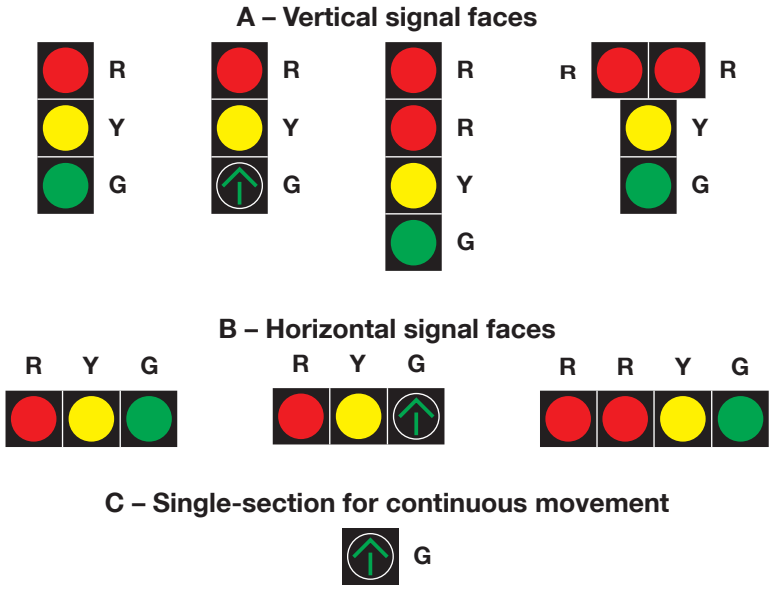
09 Within a signal face, two identical CIRCULAR RED or RED ARROW signal indications may be displayed immediately horizontally adjacent or immediately vertically adjacent to each other in a vertical signal face (see Drawing A in Figure 4E-2) or immediately horizontally adjacent to each other in a horizontal signal face (see Drawing B in Figure 4E-2) for emphasis.

10 Horizontally-arranged and vertically-arranged signal faces may be used on the same approach provided they are separated to meet the lateral separation spacing required in Section 4D.07.

Support:

11 Figure 4E-2 illustrates some of the typical arrangements of signal sections in signal faces that do not control separate turning movements. Figures 4F-1 through 4F-7 illustrate the typical arrangements of signal sections in left-turn signal faces. Figures 4F-8 through 4F-14 illustrate the typical arrangements of signal sections in right-turn signal faces.

Figure 4E-2. Typical Arrangements of Signal Sections in Signal Faces That Do Not Control Turning Movements



Section 4E.04 Positions of Signal Indications within a Vertical Signal Face

Standard:

01 **In each vertically-arranged signal face, all signal sections that display red signal indications shall be located above all signal sections that display yellow and green signal indications.**

02 **In vertically-arranged signal faces, each signal section that displays a YELLOW ARROW signal indication shall be located above the signal section that displays the GREEN ARROW signal indication to which it applies.**

03 **The relative positions of signal sections in a vertically-arranged signal face, from top to bottom, shall be as follows:**

CIRCULAR RED
Steady and/or flashing left-turn RED ARROW
Steady and/or flashing right-turn RED ARROW
CIRCULAR YELLOW
CIRCULAR GREEN
Straight-through GREEN ARROW

Steady left-turn YELLOW ARROW
Flashing left-turn YELLOW ARROW
Left-turn GREEN ARROW
Steady right-turn YELLOW ARROW
Flashing right-turn YELLOW ARROW
Right-turn GREEN ARROW

04 **If a bimodal signal section (see Section 4E.01) is used in a vertically-arranged signal face, the bimodal signal section shall occupy the same position relative to the other sections as the signal section that displays the GREEN ARROW signal indication in a vertically-arranged signal face would occupy.**

Option:

05 In a vertically-arranged signal face, signal sections that display signal indications of the same color may be arranged horizontally adjacent to each other at right angles to the basic straight line arrangement to form a clustered signal face (see Figures 4E-2, 4F-3, 4F-4, 4F-6, 4F-10, 4F-11, 4F-13, and 4F-15).

Standard:

06 **Such clusters shall be limited to the following:**

- **A. Two identical signal sections,**
- **B. Two or three different signal sections that display signal indications of the same color, or**
- **C. For only the specific case described in Section 4F.16 (see Drawing B in Figure 4F-15), two signal sections, one of which displays a GREEN ARROW signal indication and the other of which displays a flashing YELLOW ARROW signal indication.**

07 **Except as otherwise provided in Sections 4F.04, 4F.08, 4F.11, and 4F.15 for a three-section separate turn signal face with a bimodal signal section that displays a flashing YELLOW ARROW signal indication, the signal section that displays a flashing yellow signal indication during steady mode operation:**

- **A. Shall not be placed in the same vertical position as the signal section that displays a steady yellow signal indication, and**
- **B. Shall be placed below the signal section that displays a steady yellow signal indication.**

Support:

08 Section 4J.02 contains exceptions to the provisions of this Section that are applicable to pedestrian hybrid beacons.

Section 4E.05 Positions of Signal Indications within a Horizontal Signal Face

Standard:

01 **In each horizontally-arranged signal face, all signal sections that display red signal indications shall be located to the left of all signal sections that display yellow and green signal indications.**

02 **In horizontally-arranged signal faces, each signal section that displays a YELLOW ARROW signal indication shall be located to the left of the signal section that displays the GREEN ARROW signal indication to which it applies.**

03 **The relative positions of signal sections in a horizontally-arranged signal face, from left to right, shall be as follows:**

CIRCULAR RED
Steady and/or flashing left-turn RED ARROW
Steady and/or flashing right-turn RED ARROW
CIRCULAR YELLOW
Steady left-turn YELLOW ARROW
Flashing left-turn YELLOW ARROW
Left-turn GREEN ARROW
CIRCULAR GREEN
Straight-through GREEN ARROW
Steady right-turn YELLOW ARROW
Flashing right-turn YELLOW ARROW
Right-turn GREEN ARROW

04 **If a bimodal signal section (see Section 4E.01) is used in a horizontally-arranged signal face, the signal section that displays the dual left-turn arrow signal indication shall be located immediately to the right**

of the signal section that displays the CIRCULAR YELLOW signal indication, the signal section that displays the straight-through GREEN ARROW signal indication shall be located immediately to the right of the signal section that displays the CIRCULAR GREEN signal indication, and the signal section that displays the dual right-turn arrow signal indication shall be located to the right of all other signal sections.

05 **Except as otherwise provided in Sections 4F.04, 4F.08, 4F.11, and 4F.15 for a three-section separate turn signal face with a flashing YELLOW ARROW signal indication, the signal section that displays a flashing yellow signal indication during steady mode operation:**

- **A. Shall not be placed in the same horizontal position as the signal section that displays a steady yellow signal indication, and**
- **B. Shall be placed to the right of the signal section that displays a steady yellow signal indication.**

CHAPTER 4F. STEADY (STOP-AND-GO) OPERATION OF TRAFFIC CONTROL SIGNALS

Section 4F.01 Application of Steady and Flashing Signal Indications during Steady (Stop-and-Go) Operation

Standard:

01 **When a traffic control signal is being operated in a steady (stop-and-go) mode, at least one indication in each signal face shall be displayed at any given time.**

02 **A signal face(s) that controls a particular vehicular movement during any interval of a cycle shall control that same movement during all intervals of the cycle.**

03 **Steady and flashing signal indications shall be applied as follows:**

A. A steady CIRCULAR RED signal indication:

1. **Shall be displayed when it is intended to prohibit traffic, except pedestrians directed by a pedestrian signal head, from entering the intersection or other controlled area. Turning after stopping is permitted as stated in Item C.1 in Paragraph 1 of Section 4A.03.**
2. **Shall be displayed with the appropriate GREEN ARROW signal indications when it is intended to permit traffic to make a specified turn or turns, and to prohibit traffic from proceeding straight ahead through the intersection or other controlled area, except in protected only mode operation (see Sections 4F.06 and 4F.13), or in protected/permissive mode operation with separate turn signal faces (see Sections 4F.08 and 4F.15).**

B. A steady CIRCULAR YELLOW signal indication:

1. **Shall be displayed following a CIRCULAR GREEN or straight-through GREEN ARROW signal indication in the same signal face.**
2. **Shall not be displayed in conjunction with the change from the CIRCULAR RED signal indication to the CIRCULAR GREEN signal indication.**
3. **Shall be followed by a CIRCULAR RED signal indication except that, when entering preemption operation, the return to the previous CIRCULAR GREEN signal indication shall be permitted following a steady CIRCULAR YELLOW signal indication (see Section 4F.19).**
4. **Shall not be displayed to an approach from which drivers are turning left permissively using a shared signal face or making a U-turn to the left permissively using a shared signal face unless one of the following conditions exists:**
   - **(a) A steady CIRCULAR YELLOW signal indication is also simultaneously being displayed to the opposing approach;**
   - **(b) An engineering study has determined that, because of unique intersection conditions, the condition described in Item (a) cannot reasonably be implemented without causing significant operational or safety problems and that the volume of impacted left-turning or U-turning traffic is relatively low, and those left-turning or U-turning drivers are advised that a steady CIRCULAR YELLOW signal indication is not simultaneously being displayed to the opposing traffic if this operation occurs continuously by the installation of a W25-1 sign (see Section 2C.44) with the legend ONCOMING TRAFFIC HAS EXTENDED GREEN; or**
   - **(c) Drivers are advised of the operation if it occurs only occasionally, such as during a preemption sequence, by the installation of a W25-2 sign (see Section 2C.44) with the legend ONCOMING TRAFFIC MAY HAVE EXTENDED GREEN.**

C. A steady CIRCULAR GREEN signal indication shall be displayed only when it is intended to permit traffic to proceed in any direction that is lawful and practical.

D. As described in Item C.2 in Paragraph 1 of Section 4A.03, turning on a steady RED ARROW signal indication shall be permitted except when a traffic control device is in place prohibiting a turn on red.

E. A flashing RED ARROW signal indication shall be displayed as part of a steady (stop-and-go) mode of operation only when it is intended to permit traffic, after coming to a full stop, to cautiously enter the intersection to make a turn in the direction indicated by the arrow after yielding to pedestrians, if any, and/or to opposing traffic, if any.

F. A steady YELLOW ARROW signal indication:

1. **Shall be displayed in the same direction as a GREEN ARROW signal indication following a GREEN ARROW signal indication in the same signal face, unless:**
   - **(a) The GREEN ARROW signal indication and a CIRCULAR GREEN (or straight-through GREEN ARROW) signal indication terminate simultaneously in the same signal face, or**
   - **(b) The green arrow is a straight-through GREEN ARROW (see Item B.1 in this Paragraph).**
2. **Shall be displayed in the same direction as a flashing YELLOW ARROW signal indication or flashing RED ARROW signal indication following a flashing YELLOW ARROW signal indication or flashing RED ARROW signal indication in the same signal face, when the flashing arrow indication is displayed as part of a steady mode operation, if the signal face will subsequently display a steady red signal indication.**
3. **Shall not be displayed in conjunction with the change from a steady RED ARROW, flashing RED ARROW, or flashing YELLOW ARROW signal indication to a GREEN ARROW signal indication, except when entering preemption operation as provided in Item F.5(a) of this Paragraph.**
4. **Shall not be displayed when any conflicting vehicular movement has a green or yellow signal indication (except for the situation regarding U-turns to the left provided in Paragraph 4 of this Section) or any conflicting pedestrian movement has a WALKING PERSON (symbolizing WALK) or flashing UPRAISED HAND (symbolizing DONT WALK) signal indication, except that a steady left-turn (or U-turn to the left) YELLOW ARROW signal indication used to terminate a flashing left-turn (or U-turn to the left) YELLOW ARROW or a flashing left-turn (or U-turn to the left) RED ARROW signal indication in a signal face controlling a permissive left-turn (or U-turn to the left) movement as described in Sections 4F.04 and 4F.08 shall be permitted to be displayed when a CIRCULAR YELLOW signal indication is displayed for the opposing through movement. Vehicles departing in the same direction shall not be considered in conflict if, for each turn lane with moving traffic, there is a separate departure lane, and pavement markings or raised channelization clearly indicate which departure lane to use.**
5. **Shall not be displayed to terminate a flashing arrow signal indication on an approach from which drivers are turning left permissively or making a U-turn to the left permissively unless one of the following conditions exists:**
   - **(a) A steady CIRCULAR YELLOW signal indication is also simultaneously being displayed to the opposing approach;**
   - **(b) An engineering study has determined that, because of unique intersection conditions, the condition described in Item (a) cannot reasonably be implemented without causing significant operational or safety problems and that the volume of impacted left-turning or U-turning traffic is relatively low, and those left-turning or U-turning drivers are advised that a steady CIRCULAR YELLOW signal indication is not simultaneously being displayed to the opposing traffic if this operation occurs continuously by the installation of a W25-1 sign (see Section 2C.44) with the legend ONCOMING TRAFFIC HAS EXTENDED GREEN; or**
   - **(c) Drivers are advised of the operation if it occurs only occasionally, such as during a preemption sequence, by the installation of a W25-2 sign (see Section 2C.44) with the legend ONCOMING TRAFFIC MAY HAVE EXTENDED GREEN.**
6. **Shall be terminated by a RED ARROW signal indication for the same direction or a CIRCULAR RED signal indication except:**
   - **(a) When entering preemption operation, the display of a GREEN ARROW signal indication or a flashing arrow signal indication shall be permitted following a steady YELLOW ARROW signal indication.**
   - **(b) When the movement controlled by the arrow is to continue on a permissive mode basis during an immediately following signal phase, the display of a CIRCULAR GREEN signal indication or flashing YELLOW ARROW signal indication shall be permitted following a steady YELLOW ARROW signal indication. To provide a red clearance interval, it shall be permitted to display a steady left-turn RED ARROW signal indication immediately following the steady left-turn YELLOW ARROW signal indication.**

G. A flashing YELLOW ARROW signal indication shall be displayed as part of a steady (stop-and-go) mode of operation only when it is intended to permit traffic to cautiously enter the intersection to make a turn in the direction indicated by the arrow after stopping and yielding to pedestrians, if any, and/or yielding to opposing traffic, if any.

H. A steady GREEN ARROW signal indication:

1. Shall be displayed only to allow vehicular movements, in the direction indicated, that are not in conflict with other vehicles moving on a green or yellow signal indication (except for the situation regarding U-turns provided in Paragraph 4 of this Section and straight-through GREEN ARROWs provided in Paragraph 5 of this Section), even if the other vehicles are required to yield the right-of-way to the traffic moving on the GREEN ARROW signal indication, and are not in conflict with pedestrians crossing in compliance with a WALKING PERSON (symbolizing WALK) or flashing UPRAISED HAND (symbolizing DONT WALK) signal indication. Vehicles departing in the same direction shall not be considered in conflict if, for each turn lane with moving traffic, there is a separate departure lane, and pavement markings or raised channelization clearly indicate which departure lane to use.

2. Shall be displayed on a signal face that controls a left-turn movement when said movement is not in conflict with other vehicles moving on a green or yellow signal indication (except for the situation regarding U-turns provided in Paragraph 4 of this Section) and is not in conflict with pedestrians crossing in compliance with a WALKING PERSON (symbolizing WALK) or flashing UPRAISED HAND (symbolizing DONT WALK) signal indication. Vehicles departing in the same direction shall not be considered in conflict if, for each turn lane with moving traffic, there is a separate departure lane, and pavement markings or raised channelization clearly indicate which departure lane to use.

3. Shall not be required on the stem of a T-intersection or for turns from a one-way street.

Option:

04 If U-turns are permitted from the approach and a right-turn GREEN ARROW signal indication is simultaneously being displayed to road users making a right turn from the conflicting approach to the left, road users making a U-turn may be advised of the operation by the installation of a U-TURN YIELD TO RIGHT TURN (R10-16) sign (see Section 2B.59).

05 A steady straight-through GREEN ARROW signal indication may be used instead of a CIRCULAR GREEN signal indication in a signal face to discourage wrong-way turns under the following conditions, even if opposed by a simultaneous permissive left-turn movement:

A. On an approach intersecting a one-way street;
B. On an approach intersecting an interchange exit ramp;
C. On an approach with unique geometric design that prohibits turns; or
D. On an approach with pre-signals and the adjacent lanes are controlled separately (see Sections 8D.11 and 8D.12).

06 If not otherwise prohibited, steady red, yellow, and green turn arrow signal indications may be used instead of steady circular red, yellow, and green signal indications in a signal face on an approach where all traffic is required to turn or where the straight-through movement is not physically possible.

Support:

07 Section 4F.16 contains information regarding the signalization of approaches that have a combined left-turn/right-turn lane and no through movement.

08 Section 4D.07 contains information regarding limitations on left-turn arrows, right-turn arrows, and U-turn arrows in supplemental signal faces.

Standard:

09 **A straight-through RED ARROW signal indication or a straight-through YELLOW ARROW signal indication shall not be displayed on any signal face, either alone or in combination with any other signal indication.**

10 **The following combinations of signal indications shall not be simultaneously displayed on any one signal face:**

A. CIRCULAR YELLOW with CIRCULAR RED,
B. CIRCULAR GREEN with CIRCULAR RED, or
C. Straight-through GREEN ARROW with CIRCULAR RED.

11 **Except as provided in Paragraph 13 of this Section, the above combinations shall not be simultaneously displayed on an approach as a result of the combination of displays from multiple signal faces unless the display is created by a signal face(s) devoted exclusively to the control of a right-turn movement and:**

- **A. The signal face(s) controlling the right-turn movement is visibility limited from the adjacent through movement or positioned to minimize potential confusion to approaching road users, or**
- **B. A RIGHT TURN SIGNAL (R10-10) sign (see Sections 4F.09, 4F.11, 4F.13, and 4F.15) is mounted adjacent to the signal face(s) controlling the right-turn movement.**

12 **Except as provided in Paragraph 13 of this Section, the following combinations of signal indications shall not be simultaneously displayed on any one signal face or as a result of the combination of displays from multiple signal faces on an approach:**

- **A. CIRCULAR GREEN with CIRCULAR YELLOW,**
- **B. Straight-through GREEN ARROW with CIRCULAR YELLOW,**
- **C. GREEN ARROW with YELLOW ARROW pointing in the same direction,**
- **D. YELLOW ARROW with RED ARROW pointing in the same direction, or**
- **E. GREEN ARROW with RED ARROW pointing in the same direction.**

13 **If a separate signal face is provided at a pre-signal (see Section 8D.11) or at a queue cutter signal (see Section 8D.12) for a left-turn and/or right-turn lane that extends from the downstream signalized intersection back to and across a grade crossing, the following combinations of signal indications shall be permitted to be simultaneously displayed as a result of the combination of displays from multiple signal faces at the pre-signal or queue cutter signal:**

- **A. Straight-through GREEN ARROW with CIRCULAR RED,**
- **B. Straight-through GREEN ARROW with CIRCULAR YELLOW, and**
- **C. CIRCULAR YELLOW with CIRCULAR RED.**

14 **Except as otherwise provided in Sections 4F.08, 4F.15, and 4J.03, the same signal section shall not be used to display both a flashing yellow and a steady yellow indication during steady mode operation. Except as otherwise provided in Sections 4F.04, 4F.08, 4F.11, and 4F.13, the same signal section shall not be used to display both a flashing red and a steady red indication during steady mode operation.**

Guidance:

15 *No movement that creates an unexpected crossing of pathways of moving vehicles or pedestrians should be allowed during any green or yellow interval, except when all three of the following conditions are met:*

- *A. The movement involves only slight conflict, and*
- *B. Serious traffic delays are substantially reduced by permitting the conflicting movement, and*
- *C. Drivers and pedestrians subjected to the unexpected conflict are effectively warned thereof by a sign.*

Section 4F.02 Signal Indications for Left-Turn Movements – General

Support:

01 In Sections 4F.03 through 4F.08, provisions applicable to left-turn movements and left-turn lanes are also applicable to signal indications for U-turns to the left that are provided at locations where left turns are prohibited or not geometrically possible.

02 Left-turning traffic is controlled by one of four modes as follows:

- A. Permissive Only Mode—turns made on a CIRCULAR GREEN signal indication, a flashing left-turn YELLOW ARROW signal indication, or a flashing left-turn RED ARROW signal indication after stopping and yielding to pedestrians, if any, and/or yielding to opposing traffic, if any.
- B. Protected Only Mode—turns made only when a left-turn GREEN ARROW signal indication is displayed.
- C. Protected/Permissive Mode—both modes can occur on an approach during the same cycle.
- D. Variable Left-Turn Mode—the operating mode changes among the protected only mode and/or the protected/permissive mode and/or the permissive only mode during different periods of the day or as traffic conditions change.

Option:

03 In areas having a high percentage of older drivers, special consideration may be given to the use of protected only mode left-turn phasing, when appropriate.

Standard:

04 **During a permissive left-turn movement, the signal faces for through traffic on the opposing approach shall simultaneously display green or steady yellow signal indications. If pedestrians crossing the lane or**

lanes used by the permissive left-turn movement to depart the intersection are controlled by pedestrian signal heads, the signal indications displayed by those pedestrian signal heads shall not be limited to any particular display during the permissive left-turn movement.

05 **During a protected left-turn movement, the signal faces for through traffic on the opposing approach shall simultaneously display steady CIRCULAR RED signal indications. During a protected left-turn movement, a GREEN ARROW or a YELLOW ARROW signal indication shall not simultaneously be displayed to right-turning traffic on the opposing approach, except where a separate departure lane is available for each left-turn and right-turn lane with moving traffic and pavement markings or raised channelization clearly indicate which departure lane to use (see Item H.1 in Paragraph 3 in Section 4F.01). If pedestrians crossing the lane or lanes used by the protected left-turn movement to depart the intersection are controlled by pedestrian signal heads, the pedestrian signal heads shall display a steady UPRAISED HAND (symbolizing DONT WALK) signal indication during the protected left-turn movement.**

06 **If a combined left-turn/through lane exists on an approach, a left-turn GREEN ARROW or left-turn YELLOW ARROW signal indication or a flashing left-turn RED ARROW signal indication shall not be displayed to the approach simultaneously with a CIRCULAR RED signal indication for the through movement, and a left-turn RED ARROW signal indication shall not be displayed to the approach simultaneously with a CIRCULAR GREEN or CIRCULAR YELLOW signal indication for the through movement.**

07 **A yellow change interval for the left-turn movement shall not be displayed when the status of the left-turn operation is changing from permissive to protected within any given signal sequence.**

08 **If the operating mode changes among the protected only mode and/or the protected/permissive mode and/or the permissive only mode during different periods of the day or as traffic conditions change, the requirements in Sections 4F.03 through 4F.08 that are appropriate to that mode of operation shall be met, subject to the following:**

A. The CIRCULAR GREEN and CIRCULAR YELLOW signal indications shall not be displayed when operating in the protected only mode.

B. The left-turn GREEN ARROW and left-turn YELLOW ARROW signal indications shall not be displayed when operating in the permissive only mode.

Option:

09 When variable left-turn mode phasing is used for an approach that has a combined left-turn/straight-through lane and a flashing yellow arrow is used as the permissive turn display, a five-section shared left-turn signal face containing both circular and arrow indications may be used in combination with one or more separate left-turn signal faces for the mandatory left-turn lane(s), if any are present, on the same approach. The steady left-turn YELLOW ARROW signal indication and the flashing left-turn YELLOW ARROW signal indication may be displayed in the same section of the five-section shared left-turn signal face.

10 Additional static signs or changeable message signs may be used to meet the requirements for the variable left-turn mode or to inform drivers that left-turn green arrows will not be available during certain times of the day.

Support:

11 Sections 4F.03 through 4F.08 describe the use of the following two types of signal faces for controlling left-turn movements:

A. Shared signal face – This type of signal face controls both the left-turn movement and the adjacent movement (usually the through movement) and can serve as one of the two required primary signal faces for the adjacent movement. A shared signal face always displays the same color of circular indication that is displayed by the signal face or faces for the adjacent movement. If a shared signal face that provides protected/permissive mode left turns is mounted overhead for an approach that includes a mandatory left-turn lane, it is usually positioned over or slightly to the right of the extension of the lane line separating the left-turn lane from the adjacent lane. If a shared signal face that provides protected/permissive mode left turns is mounted overhead for an approach that does not include a mandatory left-turn lane, it is usually positioned over the center of the combined left-turn/straight-through lane.

B. Separate left-turn signal face – This type of signal face controls only the left-turn movement and cannot serve as one of the two required primary signal faces for the adjacent movement (usually the through movement) because it displays signal indications that are applicable only to the left-turn movement. This type of signal face is used only for an approach that has a mandatory left-turn lane(s). If a separate left-turn signal face is mounted overhead at the intersection, it is positioned over the extension of the

mandatory left-turn lane. In a separate left-turn signal face, a flashing left-turn YELLOW ARROW signal indication or a flashing left-turn RED ARROW signal indication is used to control permissive left-turn movements.

12 Section 4D.07 contains provisions regarding the lateral positioning of signal faces that control left-turn movements.

13 It is not necessary that the same mode of left-turn operation or same type of left-turn signal face be used on every approach to a signalized location. Selecting different modes and types of left-turn signal faces for the various approaches to the same signalized location is acceptable.

Option:

14 A signal face that is shared by left-turning and right-turning traffic may be provided for a combined left-turn/right-turn lane on an approach that has no through traffic (see Section 4F.16).

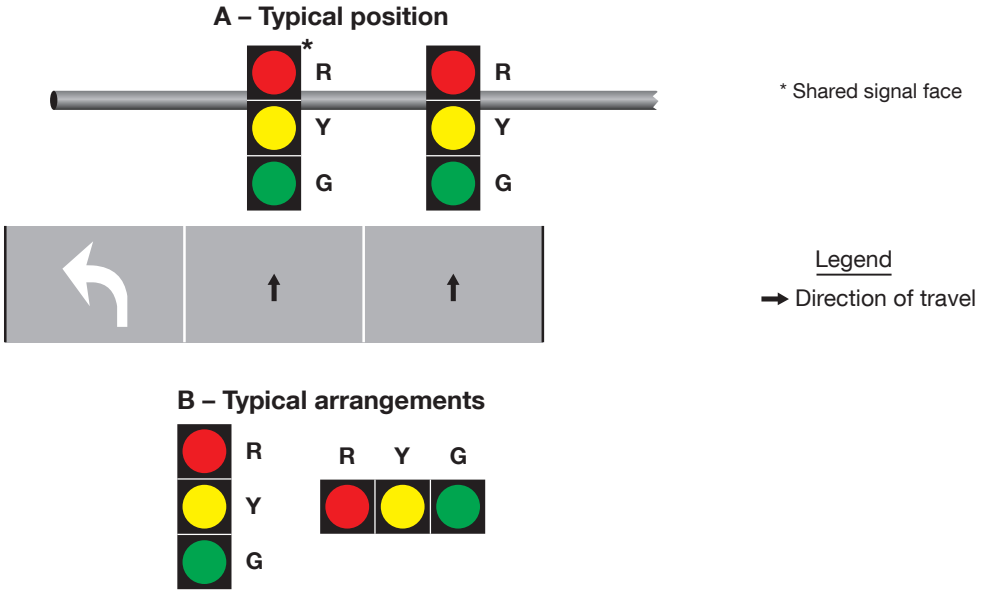
Section 4F.03 Signal Indications for Permissive Only Mode Left-Turn Movements in a Shared Signal Face

Standard:

01 **If a shared signal face is provided for a permissive only mode left turn, it shall meet the following requirements (see Figure 4F-1):**

- **A. It shall be capable of displaying the following signal indications: steady CIRCULAR RED, steady CIRCULAR YELLOW, and CIRCULAR GREEN. Only one of the three indications shall be displayed at any given time.**
- **B. During the permissive left-turn movement, a CIRCULAR GREEN signal indication shall be displayed.**
- **C. A permissive only shared signal face, regardless of where it is positioned and regardless of how many adjacent through signal faces are provided, shall always simultaneously display the same color of circular indication that the adjacent through signal face or faces display.**
- **D. If the permissive only mode is not the only left-turn mode used for the approach, the signal face shall be the same shared signal face that is used for the protected/permissive mode (see Section 4F.07) except that the left-turn GREEN ARROW and left-turn YELLOW ARROW signal indications shall not be displayed when operating in the permissive only mode.**

Figure 4F-1. Typical Position and Arrangements of Shared Signal Faces for Permissive Only Mode Left Turns



Section 4F.04 Signal Indications for Permissive Only Mode Left-Turn Movements in a Separate Signal Face

Standard:

01 **A separate left-turn signal face shall not be used for an approach that does not include a mandatory left-turn lane.**

02 **If a separate left-turn signal face is being operated in a permissive only left-turn mode, a CIRCULAR GREEN signal indication shall not be used in that face.**

03 **If a separate left-turn signal face is being operated in a permissive only left-turn mode and a flashing left-turn YELLOW ARROW signal indication is provided, it shall meet the following requirements (see Figure 4F-2):**

- **A. It shall be capable of displaying the following signal indications: steady left-turn RED ARROW, steady left-turn YELLOW ARROW, and flashing left-turn YELLOW ARROW. Only one of the three indications shall be displayed at any given time.**
- **B. During the permissive left-turn movement, a flashing left-turn YELLOW ARROW signal indication shall be displayed.**
- **C. A steady left-turn YELLOW ARROW signal indication shall be displayed following the flashing left-turn YELLOW ARROW signal indication.**
- **D. It shall be permitted to display a flashing left-turn YELLOW ARROW signal indication for a permissive left-turn movement while the signal faces for the adjacent through movement display steady CIRCULAR RED signal indications and the opposing left-turn signal faces display left-turn GREEN ARROW signal indications for a protected left-turn movement.**
- **E. During steady mode (stop-and-go) operation, the signal section that displays the steady left-turn YELLOW ARROW signal indication during change intervals shall not be used to display the flashing left-turn YELLOW ARROW signal indication for permissive left turns unless a bimodal signal section capable of alternating between the display of a steady YELLOW ARROW and a flashing YELLOW ARROW signal indication is used to operate variable left-turn mode phasing.**
- **F. During flashing mode operation (see Section 4G.01), the display of a flashing left-turn YELLOW ARROW signal indication shall be only from the signal section that displays a steady left-turn YELLOW ARROW signal indication during steady mode (stop-and-go) operation.**
- **G. If the permissive only mode is not the only left-turn mode used for the approach, the signal face shall be the same separate left-turn signal face with a flashing YELLOW ARROW signal indication that is used for the protected/permissive mode (see Section 4F.08) except that the left-turn GREEN ARROW signal indication shall not be displayed when operating in the permissive only mode.**

Option:

04 A separate left-turn signal face with a flashing left-turn RED ARROW signal indication during the permissive left-turn movement may be used for unusual geometric conditions, such as wide medians with offset left-turn lanes, but only when an engineering study determines that each and every vehicle must successively come to a full stop before making a permissive left turn.

Standard:

05 **If a separate left-turn signal face is being operated in a permissive only left-turn mode and a flashing left-turn RED ARROW signal indication is provided, it shall meet the following requirements (see Figure 4F-3):**

- **A. It shall be capable of displaying the following signal indications: steady or flashing left-turn RED ARROW, steady left-turn YELLOW ARROW, and left-turn GREEN ARROW. Only one of the three indications shall be displayed at any given time. The GREEN ARROW indication is required in order to provide a three-section signal face, but shall not be displayed during the permissive only mode.**
- **B. During the permissive left-turn movement, a flashing left-turn RED ARROW signal indication shall be displayed, thus indicating that each and every vehicle must successively come to a full stop before making a permissive left turn.**
- **C. A steady left-turn YELLOW ARROW signal indication shall be displayed following the flashing left-turn RED ARROW signal indication.**
- **D. It shall be permitted to display a flashing left-turn RED ARROW signal indication for a permissive left-turn movement while the signal faces for the adjacent through movement display**

steady CIRCULAR RED signal indications and the opposing left-turn signal faces display left-turn GREEN ARROW signal indications for a protected left-turn movement.

E. A supplementary sign shall not be required. If used, it shall be a LEFT TURN YIELD ON FLASHING RED ARROW AFTER STOP (R10-27) sign (see Section 2B.59).

Option:

06 The requirements of Item A in Paragraph 5 of this Section may be met by a vertically-arranged signal face with a horizontal cluster of two left-turn RED ARROW signal indications, the left-most of which displays a steady indication and the right-most of which displays a flashing indication (see Figure 4F-3).

Figure 4F-2. Typical Position and Arrangements of Separate Signal Faces with Flashing Yellow Arrow for Permissive Only Mode Left Turns

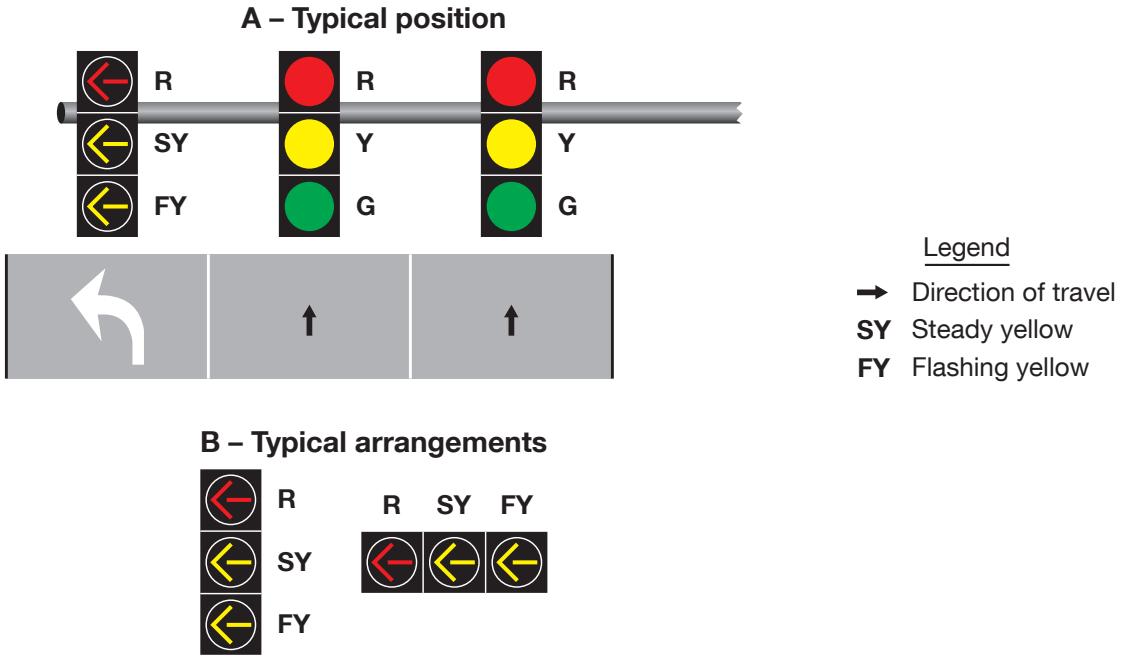
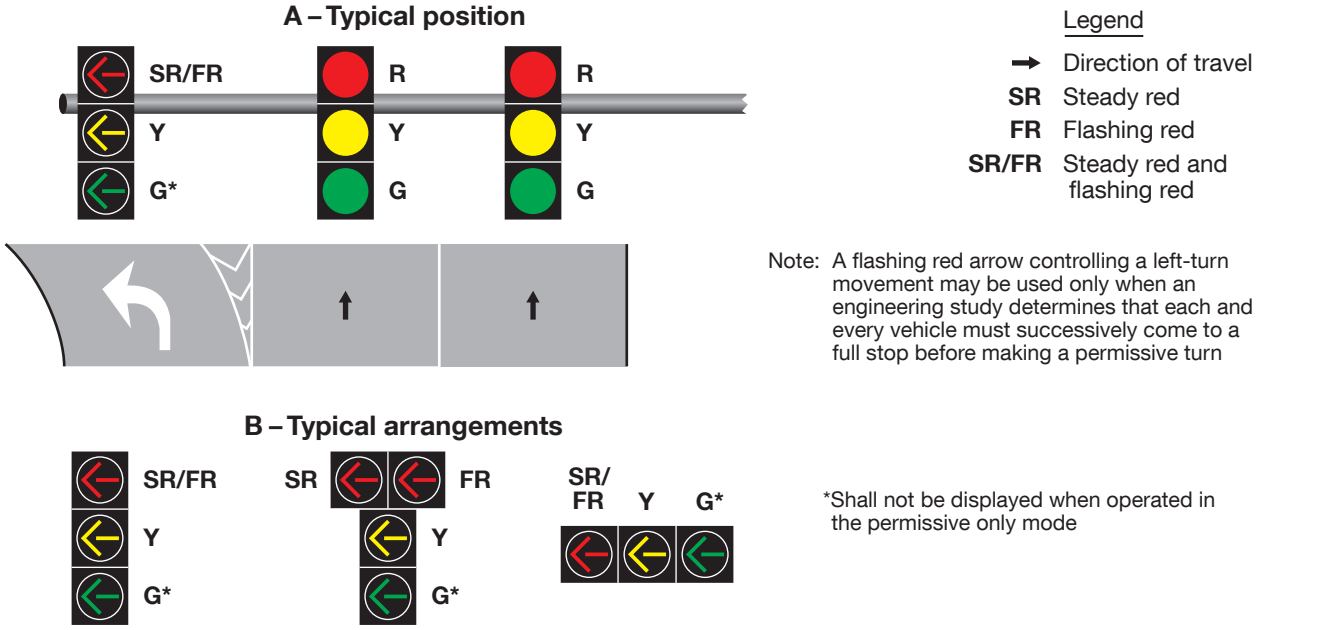


Figure 4F-3. Typical Position and Arrangements of Separate Signal Faces with Flashing Red Arrow for Permissive Only Mode and Protected/Permissive Mode Left Turns



Section 4F.05 Signal Indications for Protected Only Mode Left-Turn Movements in a Shared Signal Face

Standard:

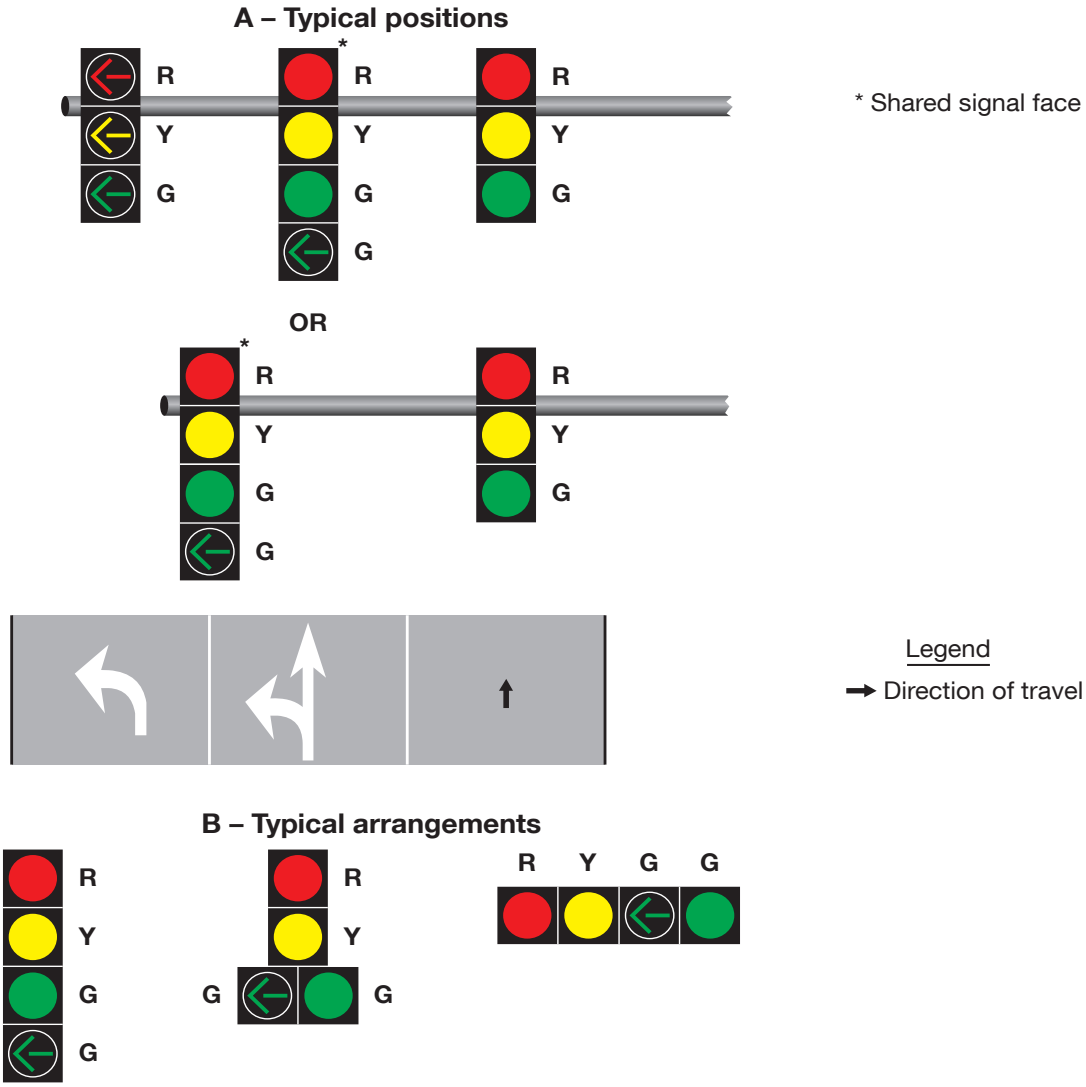
01 **A shared signal face shall not be used for protected only mode left turns unless the CIRCULAR GREEN and left-turn GREEN ARROW signal indications always begin and terminate together. If a shared signal face is provided for a protected only mode left turn, it shall meet the following requirements (see Figure 4F-4):**

- **A. It shall be capable of displaying the following signal indications: steady CIRCULAR RED, steady CIRCULAR YELLOW, CIRCULAR GREEN, and left-turn GREEN ARROW. Only one of the three colors shall be displayed at any given time.**
- **B. During the protected left-turn movement, the shared signal face shall simultaneously display both a CIRCULAR GREEN signal indication and a left-turn GREEN ARROW signal indication.**
- **C. The shared signal face shall always simultaneously display the same color of circular indication that the adjacent through signal face or faces display.**
- **D. If the protected only mode is not the only left-turn mode used for the approach, the signal face shall be the same shared signal face that is used for the protected/permissive mode (see Section 4F.07).**

Option:

02 A straight-through GREEN ARROW signal indication may be used instead of the CIRCULAR GREEN signal indication in Items A and B in Paragraph 1 of this Section on an approach where a straight-through GREEN ARROW signal indication is also used instead of a CIRCULAR GREEN signal indication in the other signal face(s) for through traffic.

Figure 4F-4. Typical Positions and Arrangements of Shared Signal Faces for Protected Only Mode Left Turns



Note: Shared signal faces shall only be used for a protected-only mode left turn if the circular green and green left-turn arrow indications always begin and terminate together

Section 4F.06 Signal Indications for Protected Only Mode Left-Turn Movements in a Separate Signal Face

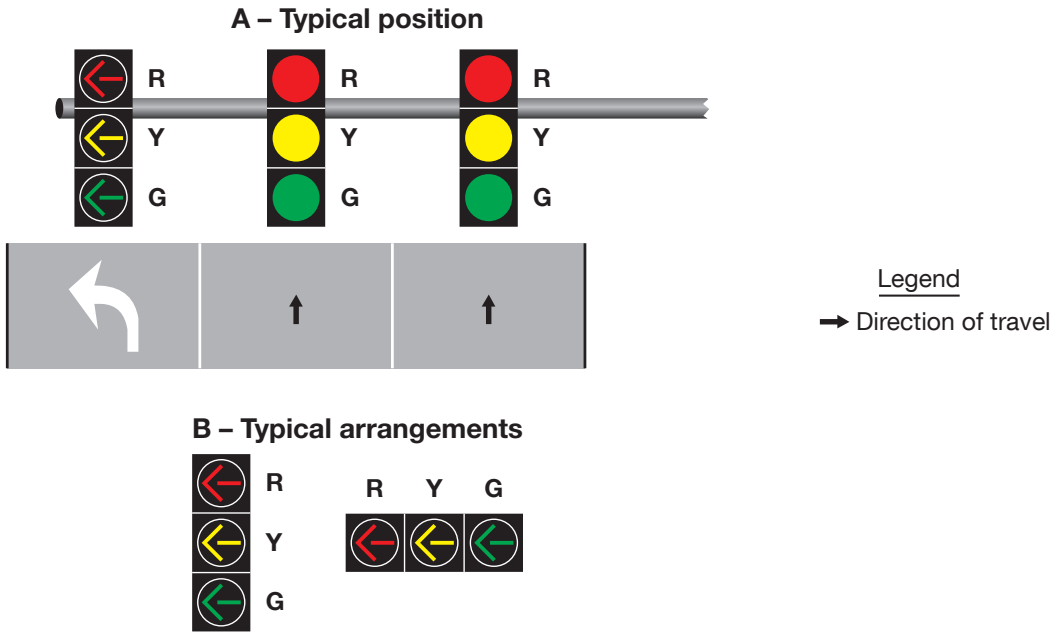
Standard:

01 **A separate left-turn signal face shall not be used for an approach that does not include a mandatory left-turn lane.**

02 **If a separate left-turn signal face is provided for a protected only mode left turn, it shall meet the following requirements (see Figure 4F-5):**

- **A. It shall be capable of displaying, the following signal indications: steady left-turn RED ARROW, steady left-turn YELLOW ARROW, and left-turn GREEN ARROW. Only one of the three indications shall be displayed at any given time.**
- **B. During the protected left-turn movement, a left-turn GREEN ARROW signal indication shall be displayed.**
- **C. A steady left-turn YELLOW ARROW signal indication shall be displayed following the left-turn GREEN ARROW signal indication.**
- **D. If the protected only mode is not the only left-turn mode used for the approach, the signal face shall be the same separate left-turn signal face that is used for the protected/permissive mode (see Section 4F.08 and Figures 4F-3 and 4F-7) except that the flashing left-turn YELLOW ARROW or flashing left-turn RED ARROW signal indication shall not be displayed when operating in the protected only mode.**

Figure 4F-5. Typical Position and Arrangements of Separate Signal Faces for Protected Only Mode Left Turns



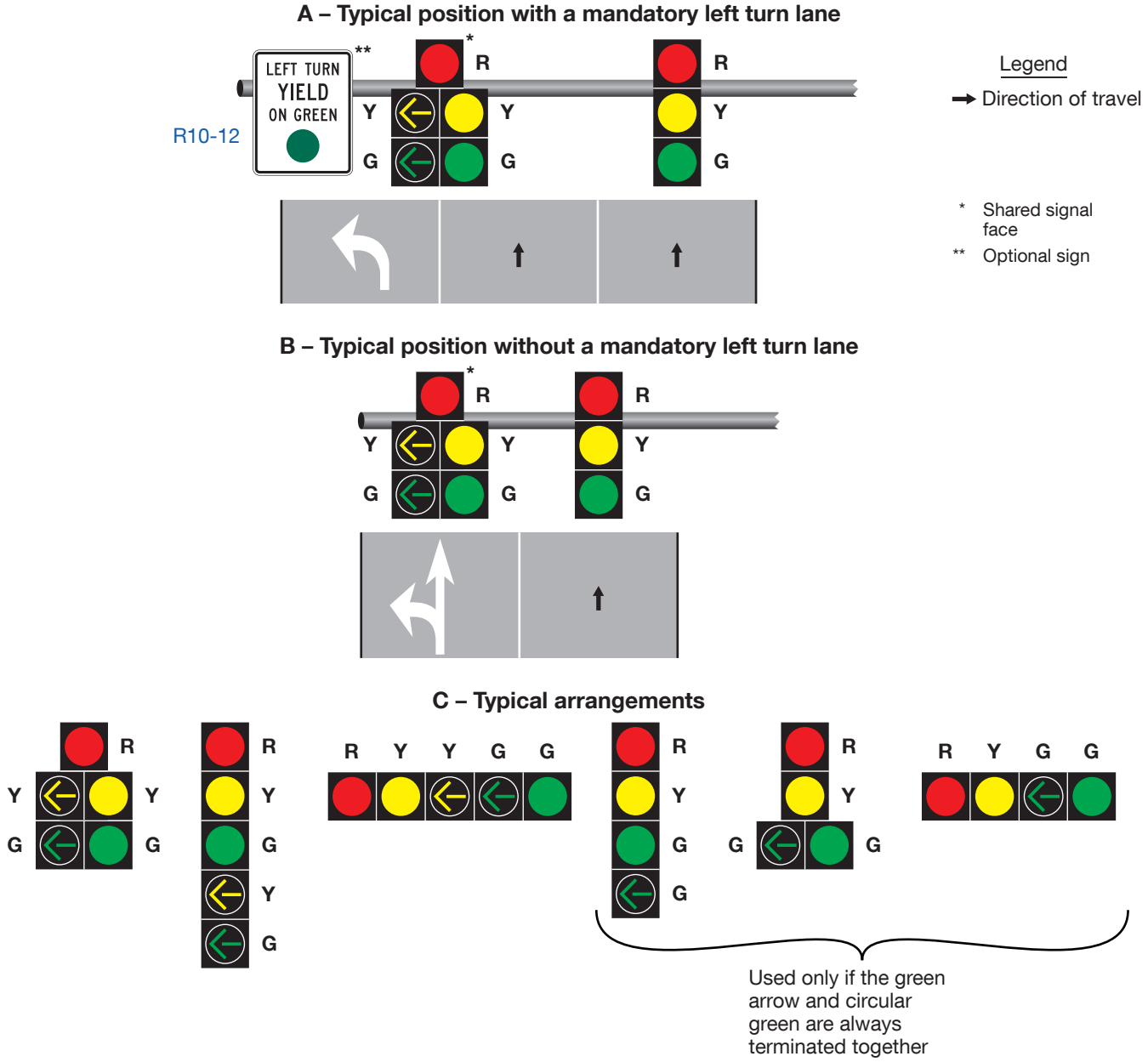
Section 4F.07 Signal Indications for Protected/Permissive Mode Left-Turn Movements in a Shared Signal Face

Standard:

01 **If a shared signal face is provided for a protected/permissive mode left turn, it shall meet the following requirements (see Figure 4F-6):**

- **A. It shall be capable of displaying the following signal indications: steady CIRCULAR RED, steady CIRCULAR YELLOW, CIRCULAR green, steady left-turn YELLOW ARROW, and left-turn GREEN ARROW. Only one of the three circular indications shall be displayed at any given time. Only one of the two arrow indications shall be displayed at any given time. If the left-turn GREEN ARROW signal indication and the CIRCULAR GREEN signal indication(s) for the adjacent through movement are always terminated together, the steady left-turn YELLOW ARROW signal indication shall not be required.**
- **B. During the protected left-turn movement, the shared signal face shall simultaneously display a left-turn GREEN ARROW signal indication and a circular signal indication that is the same color as the signal indication for the adjacent through lane on the same approach as the protected left turn.**
- **C. A steady left-turn YELLOW ARROW signal indication shall be displayed following the left-turn GREEN ARROW signal indication, unless the left-turn GREEN ARROW signal indication and the CIRCULAR GREEN signal indication(s) for the adjacent through movement are being terminated together. When the left-turn GREEN ARROW and CIRCULAR GREEN signal indications are being terminated together, the required display following the left-turn GREEN ARROW signal indication shall be either the display of a CIRCULAR YELLOW signal indication alone or the simultaneous display of the CIRCULAR YELLOW and left-turn YELLOW ARROW signal indications.**
- **D. During the permissive left-turn movement, the shared signal face shall display only a CIRCULAR GREEN signal indication.**
- **E. A protected/permissive shared signal face, regardless of where it is positioned and regardless of how many adjacent through signal faces are provided, shall always simultaneously display the same color of circular indication that the adjacent through signal face or faces display.**
- **F. A supplementary sign shall not be required. If used, it shall be a LEFT TURN YIELD ON GREEN (symbolic circular green) (R10-12) sign (see Section 2B.59).**

Figure 4F-6. Typical Position and Arrangements of Shared Signal Faces for Protected/Permissive Mode Left Turns



Section 4F.08 Signal Indications for Protected/Permissive Mode Left-Turn Movements in a Separate Signal Face

Standard:

01 **A separate left-turn signal face shall not be used for an approach that does not include a mandatory left-turn lane.**

02 **If a separate left-turn signal face is being operated in a protected/permissive left-turn mode, a CIRCULAR GREEN signal indication shall not be used in that face.**

03 **If a separate left-turn signal face is being operated in a protected/permissive left-turn mode and a flashing left-turn yellow arrow signal indication is provided, it shall meet the following requirements (see Figure 4F-7):**

A. It shall be capable of displaying the following signal indications: steady left-turn RED ARROW, steady left-turn YELLOW ARROW, flashing left-turn YELLOW ARROW, and left-turn GREEN ARROW. Only one of the four indications shall be displayed at any given time.

B. During the protected left-turn movement, a left-turn GREEN ARROW signal indication shall be displayed.

C. A steady left-turn YELLOW ARROW signal indication shall be displayed following the left-turn GREEN ARROW signal indication. It shall be permitted to display a steady left-turn RED ARROW signal indication immediately following the steady left-turn YELLOW ARROW signal indication to provide a red clearance interval.

D. During the permissive left-turn movement, a flashing left-turn YELLOW ARROW signal indication shall be displayed.

E. A steady left-turn YELLOW ARROW signal indication shall be displayed following the flashing left-turn YELLOW ARROW signal indication if the permissive left-turn movement is being terminated and the separate left-turn signal face will subsequently display a steady left-turn RED ARROW indication.

F. It shall be permitted to display a flashing left-turn YELLOW ARROW signal indication for a permissive left-turn movement while the signal faces for the adjacent through movement display steady CIRCULAR RED signal indications and the opposing left-turn signal faces display left-turn GREEN ARROW signal indications for a protected left-turn movement.

G. When a permissive left-turn movement is changing to a protected left-turn movement, a left-turn GREEN ARROW signal indication shall be displayed immediately upon the termination of the flashing left-turn YELLOW ARROW signal indication. A steady left-turn YELLOW ARROW signal indication shall not be displayed between the display of the flashing left-turn YELLOW ARROW signal indication and the display of the steady left-turn GREEN ARROW signal indication.

H. The display shall be either:

1. A four-section signal face with the steady left-turn YELLOW ARROW signal indication being displayed in a different section than the flashing left-turn YELLOW ARROW signal indication, or

2. A three-section signal face with the steady left-turn YELLOW ARROW signal indication and the flashing left-turn YELLOW ARROW signal indication being displayed in the same bimodal signal section.

I. During steady mode (stop-and-go) operation where a four-section signal face is used, the signal section that displays the steady left-turn YELLOW ARROW signal indication during change intervals shall not be used to display the flashing left-turn YELLOW ARROW signal indication for permissive left turns.

J. During flashing mode operation (see Chapter 4G) where a four-section signal face is used, the display of a flashing left-turn YELLOW ARROW signal indication shall be only from the signal section that displays a steady left-turn YELLOW ARROW signal indication during steady mode (stop-and-go) operation.

Option:

04 A bimodal signal section (capable of displaying a GREEN ARROW for the protected left-turn movement and a flashing YELLOW ARROW for the permissive left-turn movement) along with a steady left-turn YELLOW ARROW signal indication and a steady left-turn RED ARROW signal indication may be used for a separate left-turn signal face and may be considered to be a four-section signal face that is compliant with Item H.1 of Paragraph 3 of this Section.

05 A separate left-turn signal face with a flashing left-turn RED ARROW signal indication during the permissive left-turn movement may be used for unusual geometric conditions, such as wide medians with offset left-turn lanes, but only when an engineering study determines that each and every vehicle must successively come to a full stop before making a permissive left turn.

Standard:

06 **If a separate left-turn signal face is being operated in a protected/permissive left-turn mode and a flashing left-turn RED arrow signal indication is provided, it shall meet the following requirements (see Figure 4F-3):**

A. It shall be capable of displaying the following signal indications: steady or flashing left-turn RED ARROW, steady left-turn YELLOW ARROW, and left-turn GREEN ARROW. Only one of the three indications shall be displayed at any given time.

B. During the protected left-turn movement, a left-turn GREEN ARROW signal indication shall be displayed.

C. A steady left-turn YELLOW ARROW signal indication shall be displayed following the left-turn GREEN ARROW signal indication.

D. During the permissive left-turn movement, a flashing left-turn RED ARROW signal indication shall be displayed.

E. A steady left-turn YELLOW ARROW signal indication shall be displayed following the flashing left-turn RED ARROW signal indication if the permissive left-turn movement is being terminated and the separate left-turn signal face will subsequently display a steady left-turn RED ARROW indication.

F. When a permissive left-turn movement is changing to a protected left-turn movement, a left-turn GREEN ARROW signal indication shall be displayed immediately upon the termination of the flashing left-turn RED ARROW signal indication. A steady left-turn YELLOW ARROW signal indication shall not be displayed between the display of the flashing left-turn RED ARROW signal indication and the display of the steady left-turn GREEN ARROW signal indication.

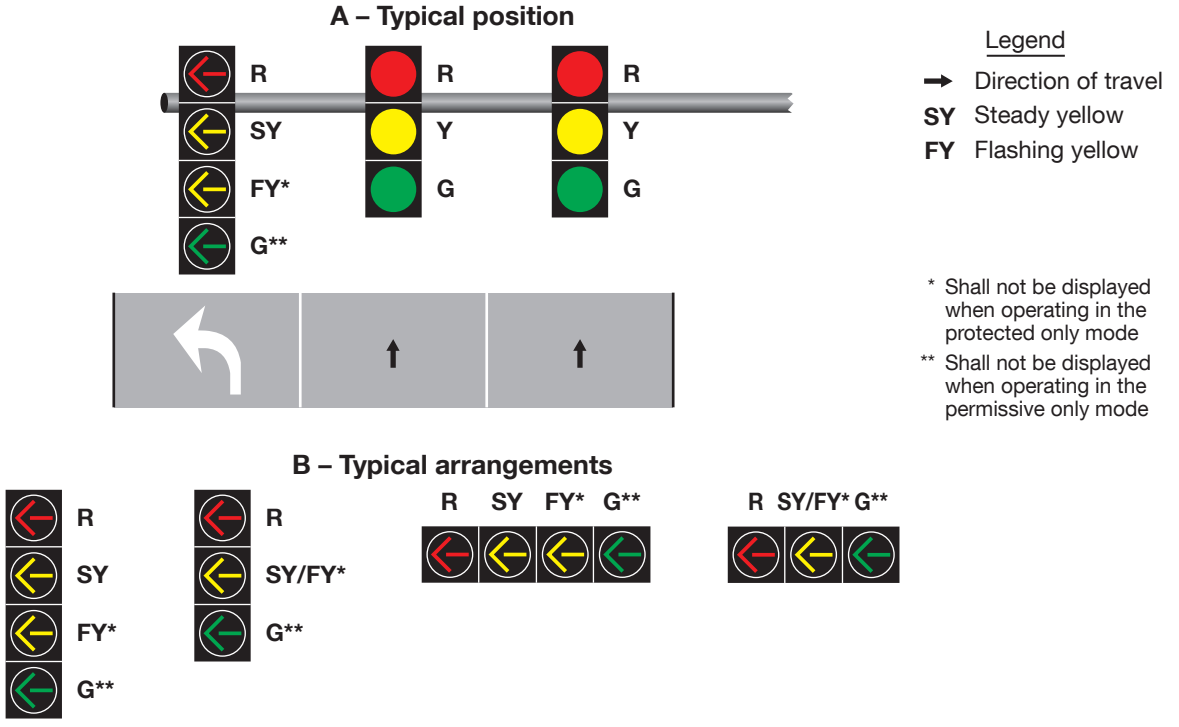
G. It shall be permitted to display a flashing left-turn RED ARROW signal indication for a permissive left-turn movement while the signal faces for the adjacent through movement display steady CIRCULAR RED signal indications and the opposing left-turn signal faces display left-turn GREEN ARROW signal indications for a protected left-turn movement.

H. A supplementary sign shall not be required. If used, it shall be a LEFT TURN YIELD ON FLASHING RED ARROW AFTER STOP (R10-27) sign (see Section 2B.59).

Option:

07 The requirements of Item A in Paragraph 6 of this Section may be met by a vertically-arranged signal face with a horizontal cluster of two left-turn RED ARROW signal indications, the left-most of which displays a steady indication and the right-most of which displays a flashing indication (see Figure 4F-3).

Figure 4F-7. Typical Position and Arrangements of Separate Signal Faces with Flashing Yellow Arrow for Protected/Permissive Mode and Variable Mode Left Turns



Section 4F.09 Signal Indications for Right-Turn Movements – General

Support:

01 In Sections 4F.10 through 4F.15, provisions applicable to right-turn movements and right-turn lanes are also applicable to signal indications for U-turns to the right that are provided at locations where right turns are prohibited or not geometrically possible.

02 Right-turning traffic is controlled by one of four modes as follows:

A. Permissive Only Mode—turns made on a CIRCULAR GREEN signal indication, a flashing right-turn YELLOW ARROW signal indication, or a flashing right-turn RED ARROW signal indication after stopping and yielding to pedestrians, if any.
B. Protected Only Mode—turns made only when a right-turn GREEN ARROW signal indication is displayed.
C. Protected/Permissive Mode—both modes occur on an approach during the same cycle.
D. Variable Right-Turn Mode—the operating mode changes among the protected only mode and/or the protected/permissive mode and/or the permissive only mode during different periods of the day or as traffic conditions change.

Standard:

03 **During a permissive right-turn movement, the signal faces, if any, that exclusively control U-turn traffic that conflicts with the permissive right-turn movement (see Item H.1 in Paragraph 3 in Section 4F.01) shall simultaneously display steady U-turn RED ARROW signal indications. If pedestrians crossing the lane or lanes used by the permissive right-turn movement to depart the intersection are controlled by pedestrian signal heads, the signal indications displayed by those pedestrian signal heads shall not be limited to any particular display during the permissive right-turn movement.**

04 **During a protected right-turn movement, a GREEN ARROW or a YELLOW ARROW signal indication shall not simultaneously be displayed to left-turning traffic on the opposing approach, except where a separate departure lane is available for each left-turn and right-turn lane with moving traffic and pavement markings or raised channelization clearly indicate which departure lane to use (see Item H.1 in Paragraph 3 in Section 4F.01). Signal faces, if any, that exclusively control U-turn traffic that conflicts with the protected right-turn movement shall simultaneously display steady RED ARROW signal indications. If pedestrians crossing the lane or lanes used by the protected right-turn movement to depart the intersection are controlled by pedestrian signal heads, the pedestrian signal heads shall display a steady UPRAISED HAND (symbolizing DONT WALK) signal indication during the protected right-turn movement.**

05 **If a combined right-turn/through lane exists on an approach, a right-turn GREEN ARROW or right-turn YELLOW ARROW signal indication or a flashing right-turn RED ARROW signal indication shall not be displayed to the approach simultaneously with a CIRCULAR RED signal indication for the through movement, and a right-turn RED ARROW signal indication shall not be displayed to the approach simultaneously with a CIRCULAR GREEN or CIRCULAR YELLOW signal indication for the through movement.**

06 **If the operating mode changes among the protected only mode and/or the protected/permissive mode and/or the permissive only mode during different periods of the day or as traffic conditions change, the requirements in Sections 4F.10 through 4F.15 that are appropriate to that mode of operation shall be met, subject to the following:**

A. The CIRCULAR GREEN and CIRCULAR YELLOW signal indications shall not be displayed when operating in the protected only mode.
B. The right-turn GREEN ARROW and right-turn YELLOW ARROW signal indications shall not be displayed when operating in the permissive only mode.

Option:

07 When variable right-turn mode phasing is used for an approach that has a combined right-turn/straight-through lane and a flashing yellow arrow is used as the permissive turn display, a five-section shared right-turn signal face containing both circular and arrow indications may be used in combination with one or more separate right-turn signal faces for the mandatory right-turn lane(s), if any are present, on the same approach. The steady right-turn YELLOW ARROW signal indication and the flashing right-turn YELLOW ARROW signal indication may be displayed in the same section of the five-section shared right-turn signal face.

08 Additional static signs or changeable message signs may be used to meet the requirements for the variable right-turn mode or to inform drivers that right-turn green arrows will not be available during certain times of the day.

Support:

09 Sections 4F.10 through 4F.15 describe the use of the following two types of signal faces for controlling right-turn movements:

A. Shared signal face – This type of signal face controls both the right-turn movement and the adjacent movement (usually the through movement) and can serve as one of the two required primary signal faces for the adjacent movement. A shared signal face always displays the same color of circular indication that is displayed by the signal face or faces for the adjacent movement.

B. Separate right-turn signal face – This type of signal face controls only the right-turn movement and cannot serve as one of the two required primary signal faces for the adjacent movement (usually the through movement) because it displays signal indications that are applicable only to the right-turn movement. If a separate right-turn signal face is mounted overhead at the intersection, it is positioned over the extension of the mandatory right-turn lane. In a separate right-turn signal face, a flashing right-turn YELLOW ARROW signal indication or a flashing right-turn RED ARROW signal indication is used to control permissive right-turn movements.

10 Section 4D.07 contains provisions regarding the lateral positioning of signal faces that control right-turn movements.

11 It is not necessary that the same mode of right-turn operation or same type of right-turn signal face be used on every approach to a signalized location. Selecting different modes and types of right-turn signal faces for the various approaches to the same signalized location is acceptable.

Option:

12 A signal face that is shared by left-turning and right-turning traffic may be provided for a combined left-turn/right-turn lane on an approach that has no through traffic (see Section 4F.16).

Section 4F.10 Signal Indications for Permissive Only Mode Right-Turn Movements in a Shared Signal Face

Standard:

01 **If a shared signal face is provided for a permissive only mode right turn, it shall meet the following requirements (see Figure 4F-8):**

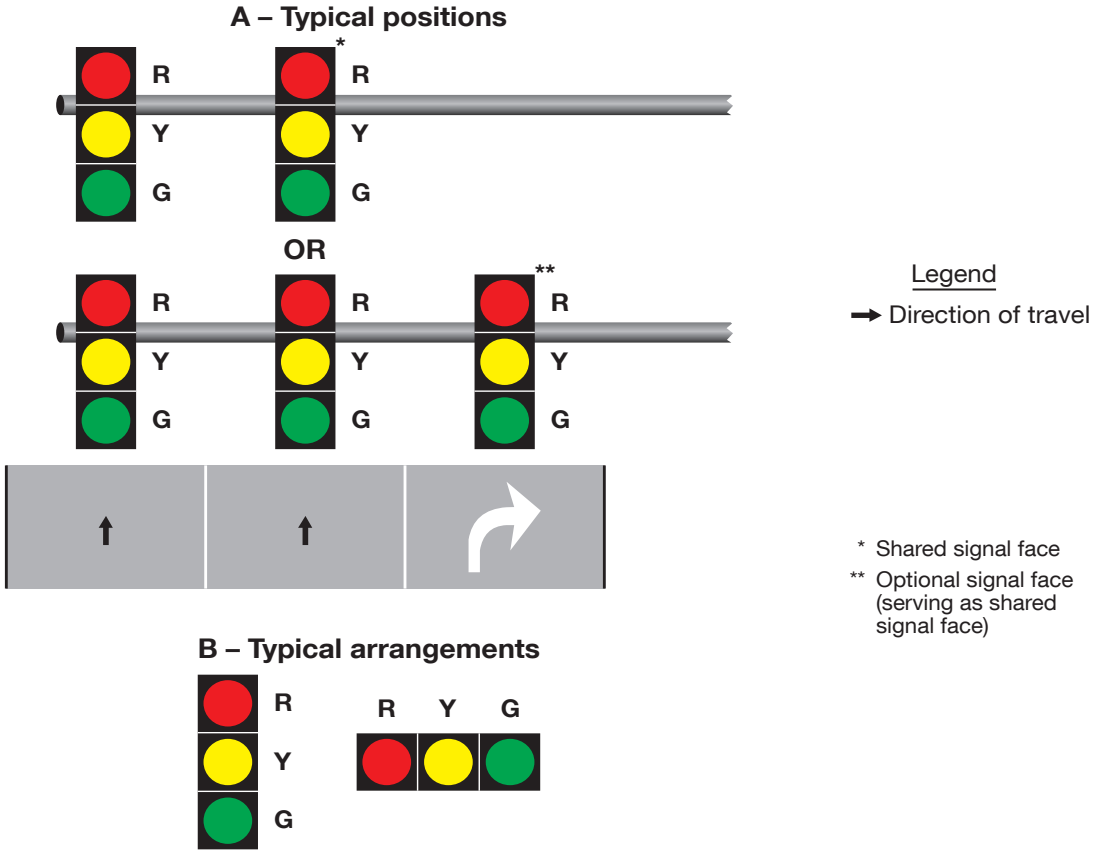
A. It shall be capable of displaying the following signal indications: steady CIRCULAR RED, steady CIRCULAR YELLOW, and CIRCULAR GREEN. Only one of the three indications shall be displayed at any given time.

B. During the permissive right-turn movement, a CIRCULAR GREEN signal indication shall be displayed.

C. A permissive only shared signal face, regardless of where it is positioned and regardless of how many adjacent through signal faces are provided, shall always simultaneously display the same color of circular indication that the adjacent through signal face or faces display.

D. If the permissive only mode is not the only right-turn mode used for the approach, the signal face shall be the same shared signal face that is used for the protected/permissive mode (see Section 4F.14) except that the right-turn GREEN ARROW and right-turn YELLOW ARROW signal indications shall not be displayed when operating in the permissive only mode.

Figure 4F-8. Typical Positions and Arrangements of Shared Signal Faces for Permissive Only Mode Right Turns



Section 4F.11 Signal Indications for Permissive Only Mode Right-Turn Movements in a Separate Signal Face

Standard:

01 **A separate right-turn signal face shall not be used for an approach that does not include a mandatory right-turn lane.**

02 **If a separate right-turn signal face is being operated in a permissive only right-turn mode, a CIRCULAR GREEN signal indication shall not be used in that face.**

03 **If a separate right-turn signal face is being operated in a permissive only right-turn mode and a flashing right-turn yellow arrow signal indication is provided, it shall meet the following requirements (see Figure 4F-9):**

- **A. It shall be capable of displaying one of the following sets of signal indications:**
  - **1. Steady right-turn RED ARROW, steady right-turn YELLOW ARROW, and flashing right-turn YELLOW ARROW. Only one of the three indications shall be displayed at any given time.**
  - **2. Steady CIRCULAR RED, steady right-turn YELLOW ARROW, and flashing right-turn YELLOW ARROW. Only one of the three indications shall be displayed at any given time. If the CIRCULAR RED signal indication is sometimes displayed when the signal faces for the adjacent through lane(s) are not displaying a CIRCULAR RED signal indication, a RIGHT TURN SIGNAL (R10-10R) sign (see Section 2B.59) shall be used unless the CIRCULAR RED signal indication in the separate right-turn signal face is shielded, hooded, louvered, positioned, or designed such that it is not readily visible to drivers in the through lane(s).**
- **B. During the permissive right-turn movement, a flashing right-turn YELLOW ARROW signal indication shall be displayed.**
- **C. A steady right-turn YELLOW ARROW signal indication shall be displayed following the flashing right-turn YELLOW ARROW signal indication.**

D. Except when a traffic control device is in place prohibiting a turn on red, vehicular traffic facing a steady CIRCULAR RED signal indication or a steady right-turn RED ARROW signal indication shall be permitted to enter the intersection to turn right after stopping. The right to proceed with the turn shall be subject to the rules applicable after making a stop at a STOP sign.

E. It shall be permitted to display a flashing right-turn YELLOW ARROW signal indication for a permissive right-turn movement while the signal faces for the adjacent through movement display steady CIRCULAR RED signal indications.

F. During steady mode (stop-and-go) operation, the signal section that displays the steady right-turn YELLOW ARROW signal indication during change intervals shall not be used to display the flashing right-turn YELLOW ARROW signal indication for permissive right turns unless a bimodal signal section capable of alternating between the display of a steady YELLOW ARROW and a flashing YELLOW ARROW signal indication is used during variable right-turn mode operation.

G. During flashing mode operation (see Chapter 4G), the display of a flashing right-turn YELLOW ARROW signal indication shall be only from the signal section that displays a steady right-turn YELLOW ARROW signal indication during steady mode (stop-and-go) operation.

H. If the permissive only mode is not the only right-turn mode used for the approach, the signal face shall be the same separate right-turn signal face with a flashing YELLOW ARROW signal indication that is used for the protected/permissive mode (see Section 4F.15) except that the right-turn GREEN ARROW signal indication shall not be displayed when operating in the permissive only mode.

Option:

04 When an engineering study determines that each and every vehicle must successively come to a full stop before making a permissive right turn, a separate right-turn signal face with a flashing right-turn RED ARROW signal indication during the permissive right-turn movement may be used.

Standard:

05 **If a separate right-turn signal face is being operated in a permissive only right-turn mode and a flashing right-turn RED arrow signal indication is provided, it shall meet the following requirements (see Figure 4F-10):**

A. It shall be capable of displaying one of the following sets of signal indications:

1. Steady or flashing right-turn RED ARROW, steady right-turn YELLOW ARROW, and right-turn GREEN ARROW. Only one of the three indications shall be displayed at any given time. The GREEN ARROW indication is required in order to provide a three-section signal face, but shall not be displayed during the permissive only mode.

2. Steady CIRCULAR RED on the left and steady right-turn RED ARROW on the right of the top position, steady right-turn YELLOW ARROW in the middle position, and right-turn GREEN ARROW in the bottom position. Only one of the four indications shall be displayed at any given time. The GREEN ARROW indication is required in order to provide three vertical positions, but shall not be displayed during the permissive only mode. If the CIRCULAR RED signal indication is sometimes displayed when the signal faces for the adjacent through lane(s) are not displaying a CIRCULAR RED signal indication, a RIGHT TURN SIGNAL (R10-10R) sign (see Section 2B.59) shall be used unless the CIRCULAR RED signal indication in the separate right-turn signal face is shielded, hooded, louvered, positioned, or designed such that it is not readily visible to drivers in the through lane(s).

B. During the permissive right-turn movement, a flashing right-turn RED ARROW signal indication shall be displayed, thus indicating that each and every vehicle must successively come to a full stop before making a permissive right turn.

C. A steady right-turn YELLOW ARROW signal indication shall be displayed following the flashing right-turn RED ARROW signal indication.

D. Except when a traffic control device is in place prohibiting a turn on red, vehicular traffic facing a steady CIRCULAR RED signal indication or a steady right-turn RED ARROW signal indication shall be permitted to enter the intersection to turn right after stopping. The right to proceed with the turn shall be subject to the rules applicable after making a stop at a STOP sign.

E. The display of a flashing right-turn RED ARROW signal indication for a permissive right-turn movement while the signal faces for the adjacent through movement display steady CIRCULAR

RED signal indications and the opposing left-turn signal faces display left-turn GREEN ARROW signal indications for a protected left-turn movement shall be permitted.

F. A supplementary sign shall not be required. If used, it shall be a RIGHT TURN YIELD ON FLASHING RED ARROW AFTER STOP (R10-27) sign (see Section 2B.59).

Option:

06 The requirements of Item A.1 in Paragraph 5 of this Section may be met by a vertically-arranged signal face with a horizontal cluster of two right-turn RED ARROW signal indications, the left-most of which displays a steady indication and the right-most of which displays a flashing indication (see Figure 4F-10).

Figure 4F-9. Typical Position and Arrangements of Separate Signal Faces with Flashing Yellow Arrow for Permissive Only Mode Right Turns

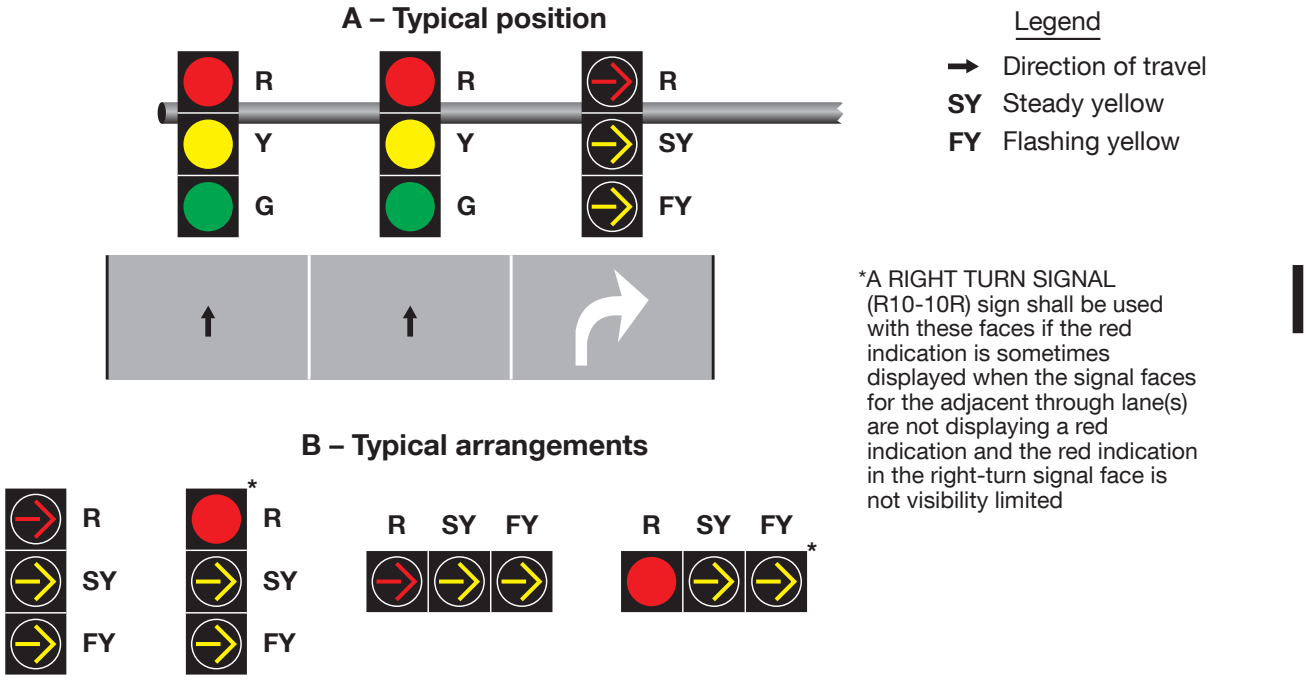
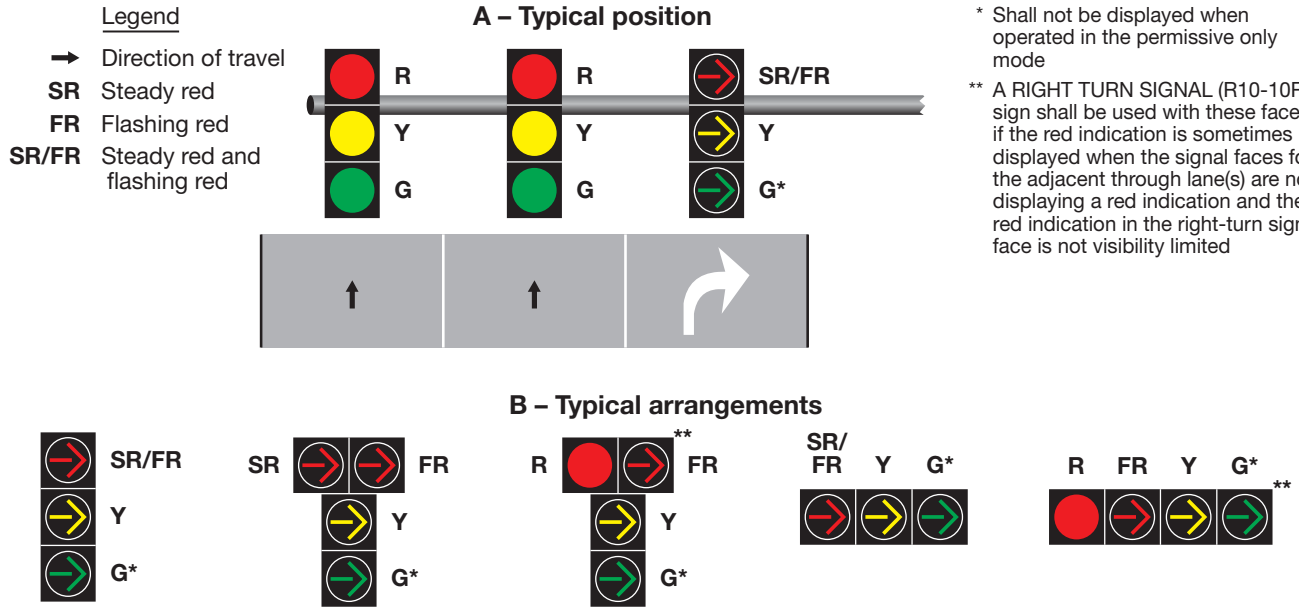


Figure 4F-10. Typical Position and Arrangements of Separate Signal Faces with Flashing Red Arrow for Permissive Only Mode and Protected/Permissive Mode Right Turns



Note: A flashing red arrow controlling a right-turn movement may be used only when an engineering study determines that each and every vehicle must successively come to a full stop before making a permissive turn

Section 4F.12 Signal Indications for Protected Only Mode Right-Turn Movements in a Shared Signal Face

Standard:

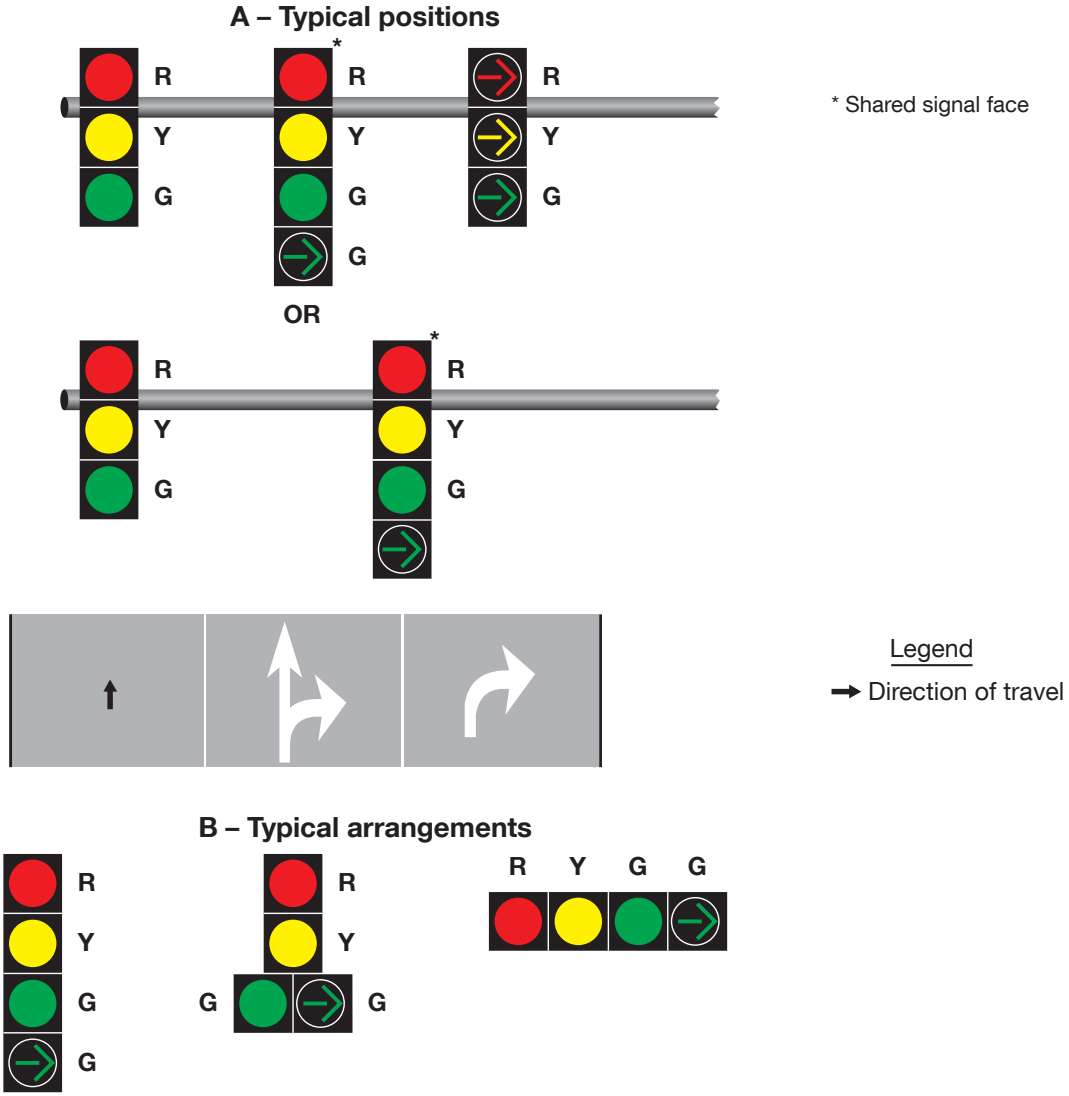
01 **A shared signal face shall not be used for protected only mode right turns unless the CIRCULAR GREEN and right-turn GREEN ARROW signal indications always begin and terminate together. If a shared signal face is provided for a protected only right turn, it shall meet the following requirements (see Figure 4F-11):**

- **A. It shall be capable of displaying the following signal indications: steady CIRCULAR RED, steady CIRCULAR YELLOW, CIRCULAR GREEN, and right-turn GREEN ARROW. Only one of the three colors shall be displayed at any given time.**
- **B. During the protected right-turn movement, the shared signal face shall simultaneously display both a CIRCULAR GREEN signal indication and a right-turn GREEN ARROW signal indication.**
- **C. The shared signal face shall always simultaneously display the same color of circular indication that the adjacent through signal face or faces display.**
- **D. If the protected only mode is not the only right-turn mode used for the approach, the signal face shall be the same shared signal face that is used for the protected/permissive mode (see Section 4F.15).**

Option:

02 A straight-through GREEN ARROW signal indication may be used instead of the CIRCULAR GREEN signal indication in Items A and B in Paragraph 1 of this Section on an approach where a straight-through GREEN ARROW signal indication is also used instead of a CIRCULAR GREEN signal indication in the other signal face(s) for through traffic.

Figure 4F-11. Typical Positions and Arrangements of Shared Signal Faces for Protected Only Mode Right Turns



Note: Shared signal faces shall only be used for a protected-only mode right turn if the circular green and green right-turn arrow indications always begin and terminate together

Section 4F.13 Signal Indications for Protected Only Mode Right-Turn Movements in a Separate Signal Face

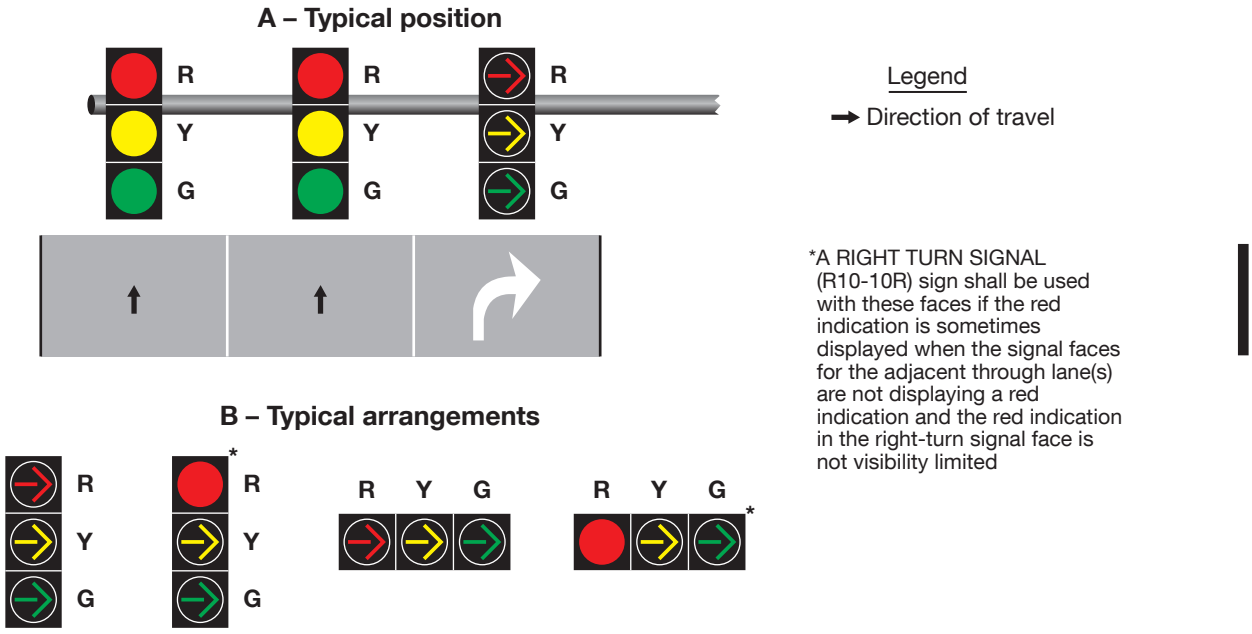
Standard:

01 **A separate right-turn signal face shall not be used for an approach that does not include a mandatory right-turn lane.**

02 **If a separate right-turn signal face is provided for a protected only mode right turn, it shall meet the following requirements (see Figure 4F-12):**

- **A. It shall be capable of displaying one of the following sets of signal indications:**
  1. **Steady right-turn RED ARROW, steady right-turn YELLOW ARROW, and right-turn GREEN ARROW. Only one of the three indications shall be displayed at any given time.**
  2. **Steady CIRCULAR RED, steady right-turn YELLOW ARROW, and right-turn GREEN ARROW. Only one of three indications shall be displayed at any given time. If the CIRCULAR RED signal indication is sometimes displayed when the signal faces for the adjacent through lane(s) are not displaying a CIRCULAR RED signal indication, a RIGHT TURN SIGNAL (R10-10R) sign (see Section 2B.59) shall be used unless the CIRCULAR RED signal indication is shielded, hooded, louvered, positioned, or designed such that it is not readily -visible to drivers in the through lane(s).**
- **B. During the protected right-turn movement, a right-turn GREEN ARROW signal indication shall be displayed.**
- **C. A steady right-turn YELLOW ARROW signal indication shall be displayed following the right-turn GREEN ARROW signal indication.**
- **D. Except when a traffic control device is in place prohibiting a turn on red, vehicular traffic facing a steady CIRCULAR RED signal indication or a steady right-turn RED ARROW signal indication shall be permitted to enter the intersection to turn right after stopping. The right to proceed with the turn shall be subject to the rules applicable after making a stop at a STOP sign.**
- **E. If the protected only mode is not the only right-turn mode used for the approach, the signal face shall be the same separate right-turn signal face that is used for the protected/permissive mode (see Section 4F.15) except that a flashing right-turn YELLOW ARROW or flashing right-turn RED ARROW signal indication shall not be displayed when operating in the protected only mode.**

Figure 4F-12. Typical Position and Arrangements of Separate Signal Faces for Protected Only Mode Right Turns



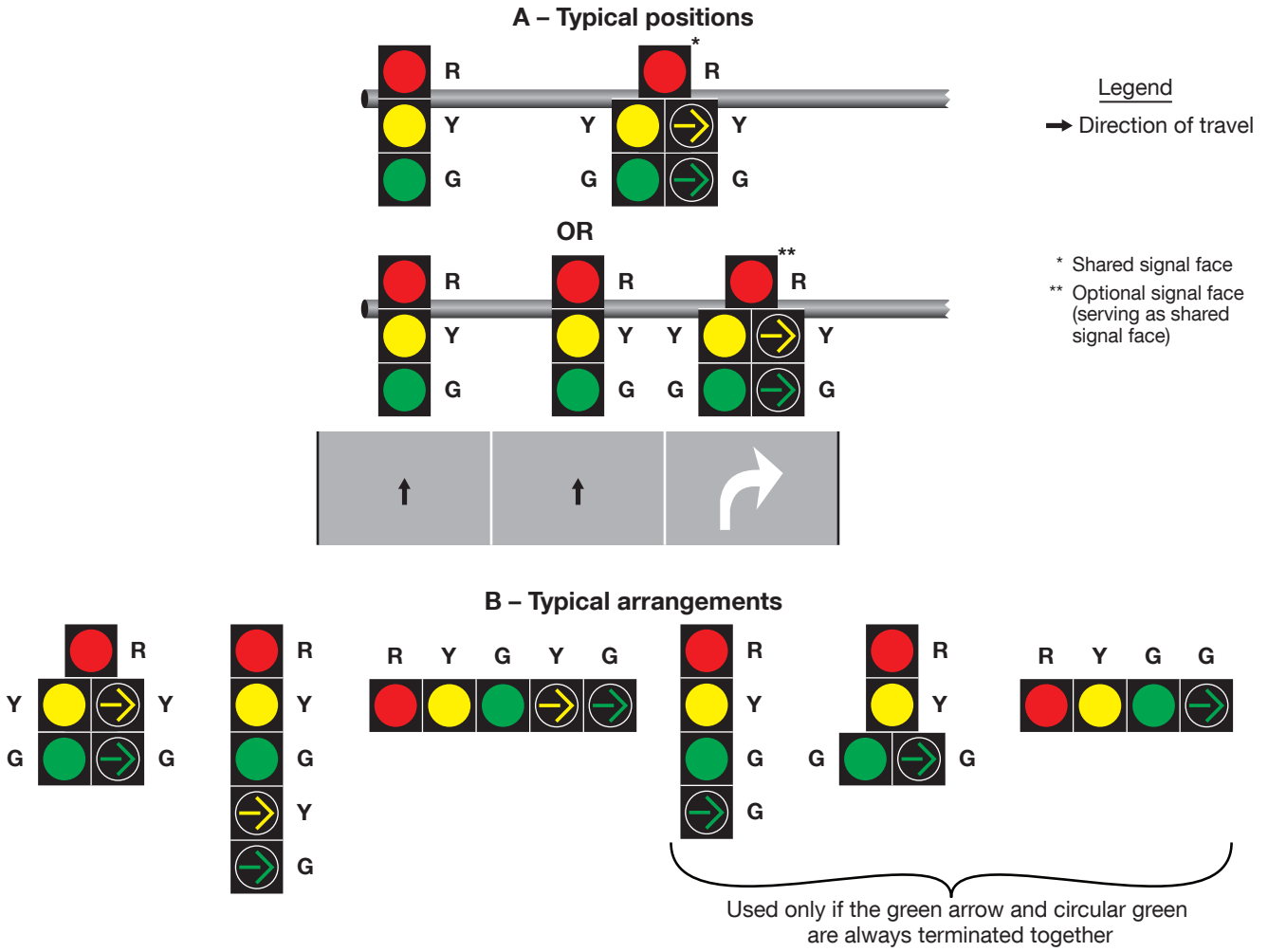
Section 4F.14 Signal Indications for Protected/Permissive Mode Right-Turn Movements in a Shared Signal Face

Standard:

01 **If a shared signal face is provided for a protected/permissive mode right turn, it shall meet the following requirements (see Figure 4F-13):**

- **A. It shall be capable of displaying the following signal indications: steady CIRCULAR RED, steady CIRCULAR YELLOW, CIRCULAR green, steady right-turn YELLOW ARROW, and right-turn GREEN ARROW. Only one of the three circular indications shall be displayed at any given time. Only one of the two arrow indications shall be displayed at any given time. If the right-turn GREEN ARROW signal indication and the CIRCULAR GREEN signal indication(s) for the adjacent through movement are always terminated together, the steady right-turn YELLOW ARROW signal indication shall not be required.**
- **B. During the protected right-turn movement, the shared signal face shall simultaneously display a right-turn GREEN ARROW signal indication and a circular signal indication that is the same color as the signal indication for the adjacent through lane on the same approach as the protected right turn.**
- **C. A steady right-turn YELLOW ARROW signal indication shall be displayed following the right-turn GREEN ARROW signal indication, unless the right-turn GREEN ARROW signal indication and the CIRCULAR GREEN signal indication(s) for the adjacent through movement are being terminated together. When the right-turn GREEN ARROW and CIRCULAR GREEN signal indications are being terminated together, the required display following the right-turn GREEN ARROW signal indication shall be either the display of a CIRCULAR YELLOW signal indication alone or the simultaneous display of the CIRCULAR YELLOW and right-turn YELLOW ARROW signal indications.**
- **D. During the permissive right-turn movement, the shared signal face shall display only a CIRCULAR GREEN signal indication.**
- **E. A protected/permissive shared signal face, regardless of where it is positioned and regardless of how many adjacent through signal faces are provided, shall always simultaneously display the same color of circular indication that the adjacent through signal face or faces display.**

Figure 4F-13. Typical Positions and Arrangements of Shared Signal Faces for Protected/Permissive Mode Right Turns



Section 4F.15 Signal Indications for Protected/Permissive Mode Right-Turn Movements in a Separate Signal Face

Standard:

01 **A separate right-turn signal face shall not be used for an approach that does not include a mandatory right-turn lane.**

02 **If a separate right-turn signal face is being operated in a protected/permissive right-turn mode, a CIRCULAR GREEN signal indication shall not be used in that face.**

03 **If a separate right-turn signal face is being operated in a protected/permissive right-turn mode and a flashing right-turn yellow arrow signal indication is provided, it shall meet the following requirements (see Figure 4F-14):**

A. It shall be capable of displaying one of the following sets of signal indications:

1. Steady right-turn RED ARROW, steady right-turn YELLOW ARROW, flashing right-turn YELLOW ARROW, and right-turn GREEN ARROW. Only one of the four indications shall be displayed at any given time.

2. Steady CIRCULAR RED, steady right-turn YELLOW ARROW, flashing right-turn YELLOW ARROW, and right-turn GREEN ARROW. Only one of the four indications shall be displayed at any given time. If the CIRCULAR RED signal indication is sometimes displayed when the signal faces for the adjacent through lane(s) are not displaying a CIRCULAR RED signal indication, a RIGHT TURN SIGNAL (R10-10R) sign (see Section 2B.59) shall be used unless the CIRCULAR RED signal indication in the separate right-turn

signal face is shielded, hooded, louvered, positioned, or designed such that it is not readily visible to drivers in the through lane(s).

B. During the protected right-turn movement, a right-turn GREEN ARROW signal indication shall be displayed.

C. A steady right-turn YELLOW ARROW signal indication shall be displayed following the right-turn GREEN ARROW signal indication. It shall be permitted to display a steady right-turn RED ARROW signal indication immediately following the steady right-turn YELLOW ARROW signal indication to provide a red clearance interval.

D. During the permissive right-turn movement, a flashing right-turn YELLOW ARROW signal indication shall be displayed.

E. A steady right-turn YELLOW ARROW signal indication shall be displayed following the flashing right-turn YELLOW ARROW signal indication if the permissive right-turn movement is being terminated and the separate right-turn signal face will subsequently display a steady red indication.

F. When a permissive right-turn movement is changing to a protected right-turn movement:

1. If a permissive left-turn movement from the opposing approach is being terminated simultaneously with the termination of the permissive right-turn movement, a steady right-turn YELLOW ARROW signal indication shall be displayed following the flashing right-turn YELLOW ARROW signal indication. To provide a red clearance interval, it shall be permitted to display a steady right-turn RED ARROW signal indication immediately following the steady right-turn YELLOW ARROW signal indication.

2. If a permissive left-turn movement from the opposing approach that is being terminated simultaneously with the termination of the permissive right-turn movement is not present, a right-turn GREEN ARROW signal indication shall be displayed immediately upon the termination of the flashing right-turn YELLOW ARROW signal indication. In this situation, a steady right-turn YELLOW ARROW signal indication shall not be displayed between the display of the flashing right-turn YELLOW ARROW signal indication and the display of the steady right-turn GREEN ARROW signal indication.

G. Except when a traffic control device is in place prohibiting a turn on red, vehicular traffic facing a steady CIRCULAR RED signal indication or a steady right-turn RED ARROW signal indication shall be permitted to enter the intersection to turn right after stopping. The right to proceed with the turn shall be subject to the rules applicable after making a stop at a STOP sign.

H. It shall be permitted to display a flashing right-turn YELLOW ARROW signal indication for a permissive right-turn movement while the signal faces for the adjacent through movement display steady CIRCULAR RED signal indications.

I. The display shall be either:

1. A four-section signal face with the steady right-turn YELLOW ARROW signal indication being displayed in a different section than the flashing right-turn YELLOW ARROW signal indication, or

2. A three-section signal face with the steady right-turn YELLOW ARROW signal indication and the flashing right-turn YELLOW ARROW signal indication being displayed in the same bimodal signal section.

J. During steady mode (stop-and-go) operation where a four-section signal face is used, the signal section that displays the steady right-turn YELLOW ARROW signal indication during change intervals shall not be used to display the flashing right-turn YELLOW ARROW signal indication for permissive right turns.

K. During flashing mode operation (see Chapter 4G) where a four-section signal face is used, the display of a flashing right-turn YELLOW ARROW signal indication shall be only from the signal section that displays a steady right-turn YELLOW ARROW signal indication during steady mode (stop-and-go) operation.

Option:

04 A bimodal signal section (capable of displaying a GREEN ARROW for the protected right-turn movement and a flashing YELLOW ARROW for the permissive right-turn movement) along with a steady right-turn YELLOW ARROW signal indication and a steady right-turn RED ARROW signal indication may be used for a separate right-turn signal face and may be considered to be a four-section signal face that is compliant with Item I.1 of Paragraph 3 of this Section.

05 When an engineering study determines that each and every vehicle must successively come to a full stop before making a permissive right turn, a separate signal face that has a flashing right-turn RED ARROW signal indication during the permissive right-turn movement may be used.

Standard:

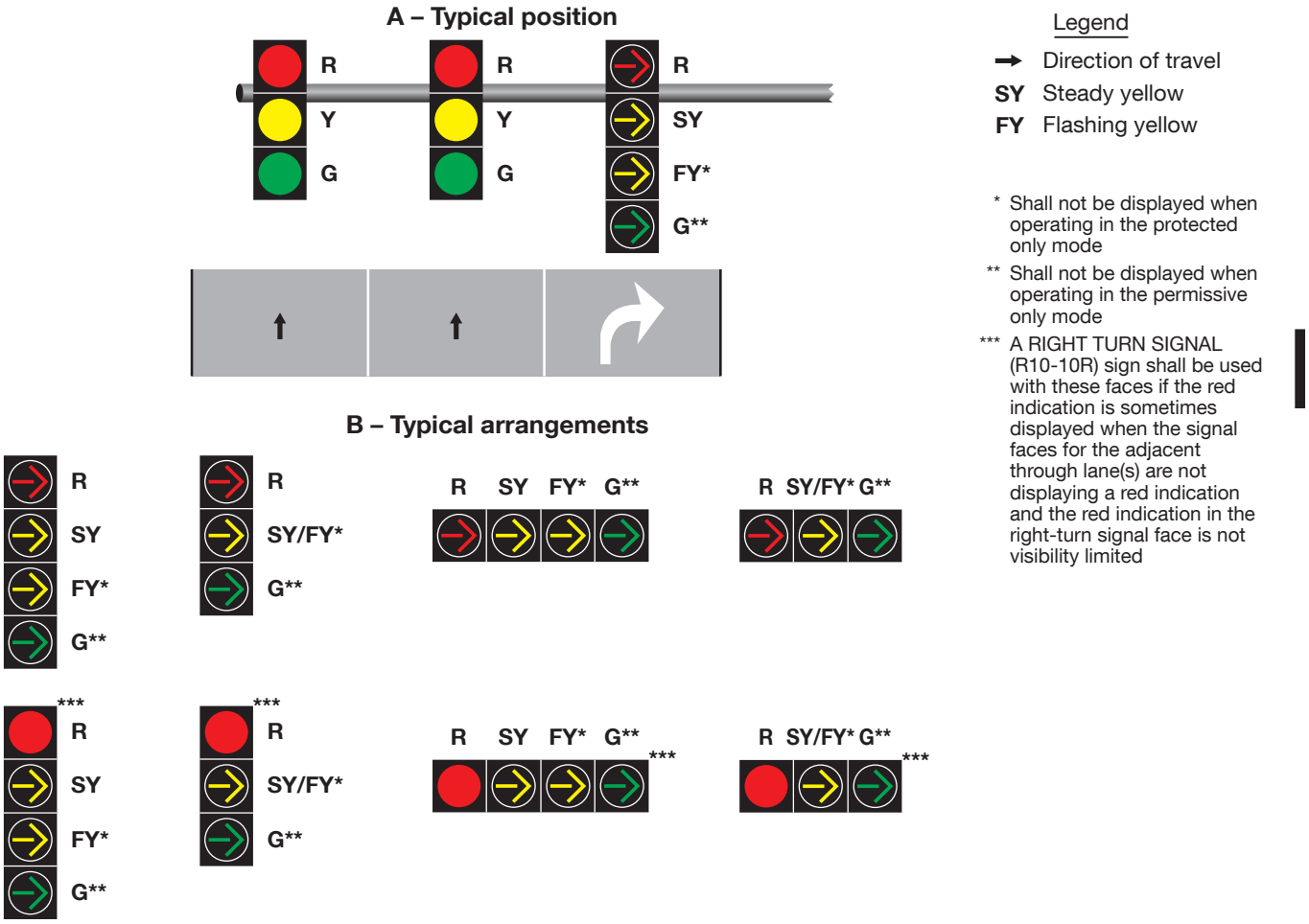
06 **If a separate right-turn signal face is being operated in a protected/permissive right-turn mode and a flashing right-turn RED arrow signal indication is provided, it shall meet the following requirements (see Figure 4F-10):**

- **A. It shall be capable of displaying one of the following sets of signal indications:**
  1. **Steady or flashing right-turn RED ARROW, steady right-turn YELLOW ARROW, and right-turn GREEN ARROW. Only one of the three indications shall be displayed at any given time.**
  2. **Steady CIRCULAR RED on the left and steady or flashing right-turn RED ARROW on the right of the top position, steady right-turn YELLOW ARROW in the middle position, and right-turn GREEN ARROW in the bottom position. Only one of the four indications shall be displayed at any given time. If the CIRCULAR RED signal indication is sometimes displayed when the signal faces for the adjacent through lane(s) are not displaying a CIRCULAR RED signal indication, a RIGHT TURN SIGNAL (R10-10R) sign (see Section 2B.59) shall be used unless the CIRCULAR RED signal indication in the separate right-turn signal face is shielded, hooded, louvered, positioned, or designed such that it is not readily visible to drivers in the through lane(s).**
- **B. During the protected right-turn movement, a right-turn GREEN ARROW signal indication shall be displayed.**
- **C. A steady right-turn YELLOW ARROW signal indication shall be displayed following the right-turn GREEN ARROW signal indication.**
- **D. During the permissive right-turn movement, the separate right-turn signal face shall display a flashing right-turn RED ARROW signal indication.**
- **E. A steady right-turn YELLOW ARROW signal indication shall be displayed following the flashing right-turn RED ARROW signal indication if the permissive right-turn movement is being terminated and the separate right-turn signal face will subsequently display a steady red indication.**
- **F. When a permissive right-turn movement is changing to a protected right-turn movement, a right-turn GREEN ARROW signal indication shall be displayed immediately upon the termination of the flashing right-turn RED ARROW signal indication. A steady right-turn YELLOW ARROW signal indication shall not be displayed between the display of the flashing right-turn RED ARROW signal indication and the display of the steady right-turn GREEN ARROW signal indication.**
- **G. Except when a traffic control device is in place prohibiting a turn on red, vehicular traffic facing a steady CIRCULAR RED signal indication or a steady right-turn RED ARROW signal indication shall be permitted to enter the intersection to turn right after stopping. The right to proceed with the turn shall be subject to the rules applicable after making a stop at a STOP sign.**
- **H. It shall be permitted to display a flashing right-turn RED ARROW signal indication for a permissive right-turn movement while the signal faces for the adjacent through movement display steady CIRCULAR RED signal indications and the opposing left-turn signal faces display left-turn GREEN ARROW signal indications for a protected left-turn movement.**
- **I. A supplementary sign shall not be required. If used, it shall be a RIGHT TURN YIELD ON FLASHING RED ARROW AFTER STOP (R10-27) sign (see Section 2B.59).**

Option:

07 The requirements of Item A.1 in Paragraph 6 of this Section may be met by a vertically-arranged signal face with a horizontal cluster of two right-turn RED ARROW signal indications, the left-most of which displays a steady indication and the right-most of which displays a flashing indication (see Figure 4F-10).

Figure 4F-14. Typical Position and Arrangements of Separate Signal Faces with Flashing Yellow Arrow for Protected/Permissive Mode and Variable Mode Right Turns



Section 4F.16 Signal Indications for Approaches with No Through Movement

Support:

01 The provisions of this Section apply only to approaches where no through movement exists, such as the stem of a T-intersection or where the opposite approach is a one-way roadway in the opposing direction. Rev. 1

Standard:

02 **Except for single-lane approaches, a minimum of two primary signal faces shall be provided for the signalized turning movement that is considered to be the major movement from the approach (see Section 4D.05).**

Option:

03 The required two primary signal faces and any supplemental primary signal faces may continuously display a steady CIRCULAR RED signal indication while steady or flashing YELLOW and steady GREEN ARROW signal indications are displayed during times when the traffic control signal is being operated in the steady (stop-and-go) mode. The continuous display of steady CIRCULAR RED is intended to reinforce that there is no through movement for safety-critical locations.

Standard:

04 **CIRCULAR GREEN and CIRCULAR YELLOW signal indications shall not be displayed to an approach with no through movement if:**

A. The posted or statutory speed limit on the approach is 35 mph or higher,

B. The one-way roadway that opposes the approach is an exit ramp from a freeway or expressway, or

C. The one-way roadway that opposes the approach has a posted or statutory speed limit of 35 mph or higher.

Support:

05 A lane from which left-turn and right-turn movements can both be made is sometimes provided on an approach that has no through movement, either as the only approach lane or as one of several approach lanes.

Option:

06 If all of the lanes on the approach are designated as mandatory turn lanes and no lane is designated as a combined 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 each may be operated in one or more of the modes of operation as described in Sections 4F.02 through 4F.15.

Standard:

07 **When a combined left-turn/right-turn lane exists on an approach, the left-turn and right-turn movements shall start and terminate simultaneously and the red signal indication used in each of the signal faces on the approach shall be a CIRCULAR RED.**

Support:

08 This requirement for the use of CIRCULAR RED signal indications in signal faces for approaches having a combined lane for left-turn and right-turn movements is a specific exception to other provisions in this Chapter that would otherwise require the use of RED ARROW signal indications.

Standard:

09 **The signal faces provided for an approach with a combined left-turn/right-turn lane and no through movement shall be one of the following:**

A. Except as provided in Paragraph 6 of Section 4F.01 and Paragraph 4 of this Section, two or more signal faces, each capable of displaying CIRCULAR RED, CIRCULAR YELLOW, and CIRCULAR GREEN signal indications, shall be provided for the approach. This display shall be permissible regardless of the number of mandatory left-turn and/or right-turn lanes that exist on the approach in addition to the combined left-turn/right-turn lane and regardless of whether or not there are pedestrian or opposing vehicular movements that conflict with the left-turn or right-turn movements. However, if there is an opposing approach and the signal phasing protects the left-turn movement on the approach with the combined left-turn/right-turn lane from conflicts with the opposing vehicular movements and any signalized pedestrian movements, a left-turn GREEN ARROW signal indication shall also be included in the left-most signal face and shall be displayed simultaneously with the CIRCULAR GREEN signal indication.

B. If the approach has one or more mandatory turn lanes in addition to the combined left-turn/right-turn lane and there is no conflict with a signalized vehicular or pedestrian movement, and GREEN ARROW signal indications are used in place of CIRCULAR GREEN signal indications on the approach, the signal faces for the approach shall be:

1. A signal face(s) capable of displaying CIRCULAR RED, YELLOW ARROW, and GREEN ARROW signal indications for the mandatory turn lane(s), with the arrows pointing in the direction of the turn, and

2. A shared left-turn/right-turn signal face capable of displaying CIRCULAR RED, left-turn YELLOW ARROW, left-turn GREEN ARROW, right-turn YELLOW ARROW, and right-turn GREEN ARROW signal indications, in an arrangement of signal sections that complies with the provisions of Section 4E.04 or 4E.05.

C. If the approach has one or more mandatory turn lanes in addition to the combined 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 of this Paragraph, 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:

10 Figure 4F-15 illustrates application of these Standards on approaches that have only a combined left-turn/right-turn lane, and on approaches that have one or more mandatory turn lanes in addition to the combined left-turn/right-turn lane.

Option:

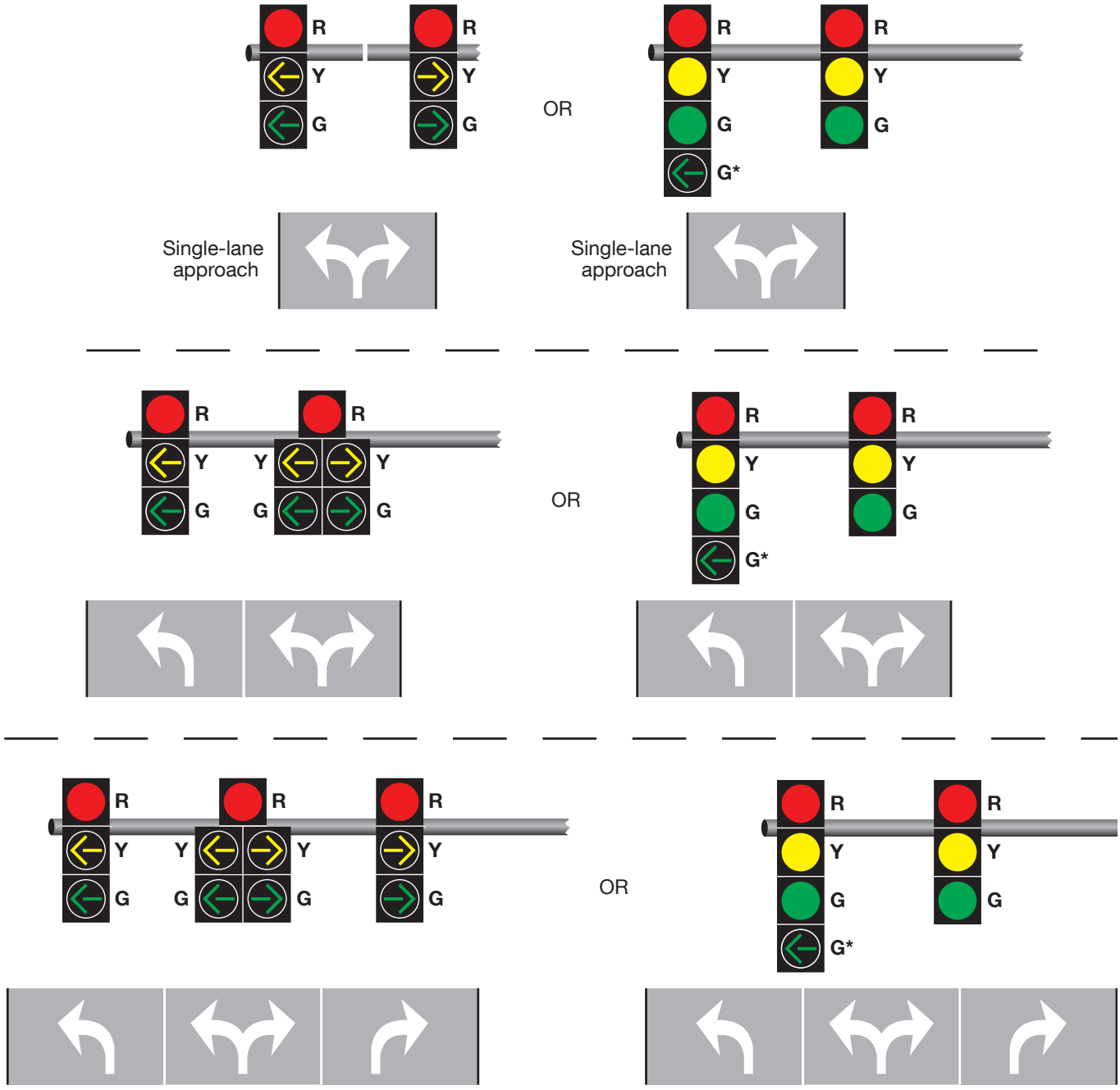
11 If the lane-use regulations on an approach are variable such that at certain times all of the lanes on the approach are designated as mandatory turn lanes and no lane is designated as a combined left-turn/right-turn lane:

A. During the times that no lane is designated as a combined 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 4F.02 through 4F.15; and

B. If a protected/permissive mode is used, the operation of the shared left-turn/right-turn signal face provided in Paragraph 9 may be modified to display the steady left-turn (right-turn) YELLOW ARROW signal indication and the flashing left-turn (right-turn) YELLOW ARROW signal indication in the same section in order to not exceed the maximum of five sections per signal face provided in Section 4E.03.

Figure 4F-15. Signal Indications for Approaches with Combined Left-Turn/Right-Turn Lane and No Through Movement (Sheet 1 of 3)

A – No conflicting vehicular or pedestrian movements



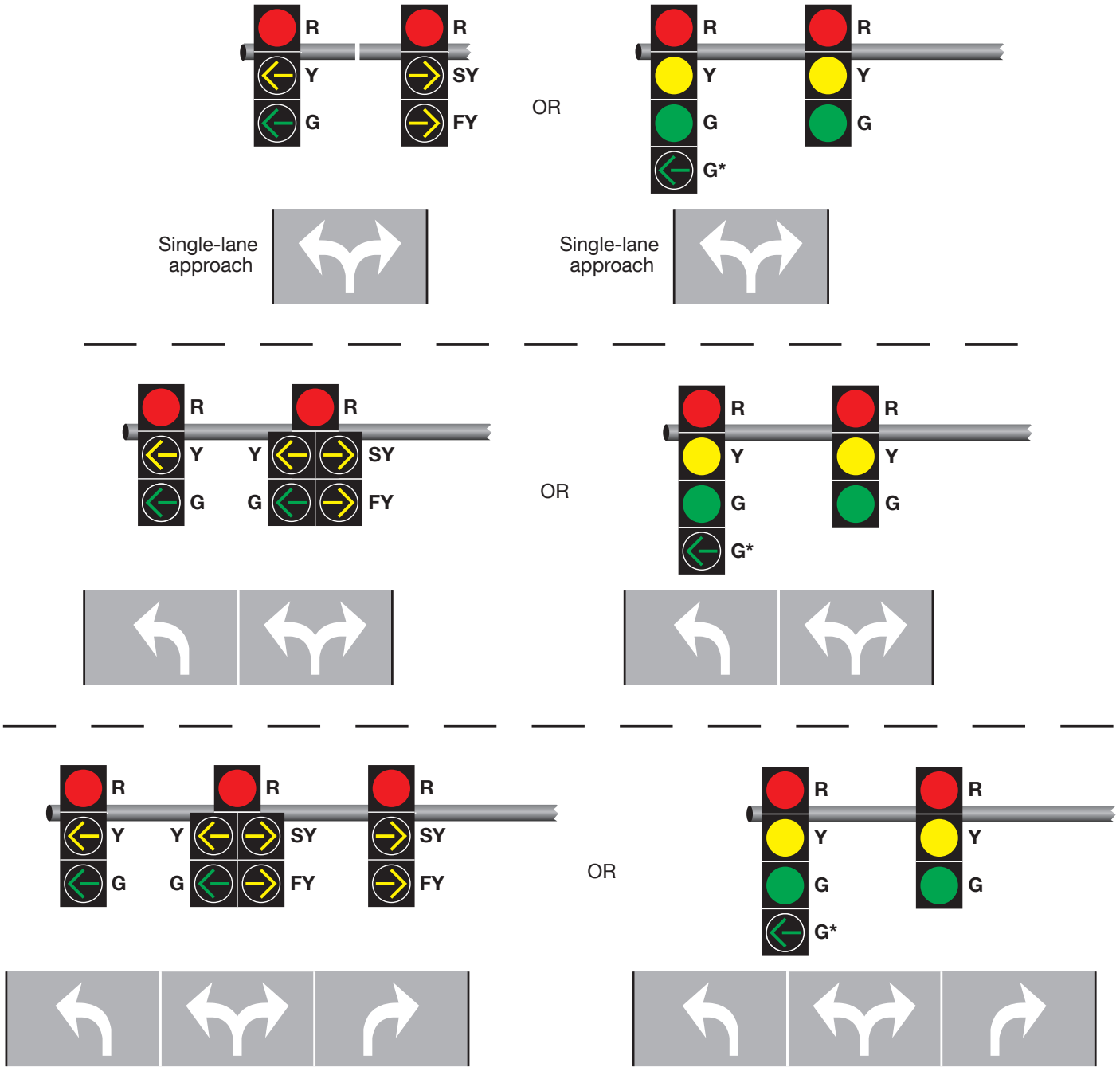
Notes:

1. Horizontally-aligned signal faces may also be used.
2. Shared signal faces may also be 5 sections in a vertical straight line instead of a cluster.

*Left-turn GREEN ARROW section shall be included if there is an opposing one-way approach and the signal phasing eliminates conflicts.

Figure 4F-15. Signal Indications for Approaches with Combined Left-Turn/Right-Turn Lane and No Through Movement (Sheet 2 of 3)

B – Pedestrian or vehicular conflict with one turn movement



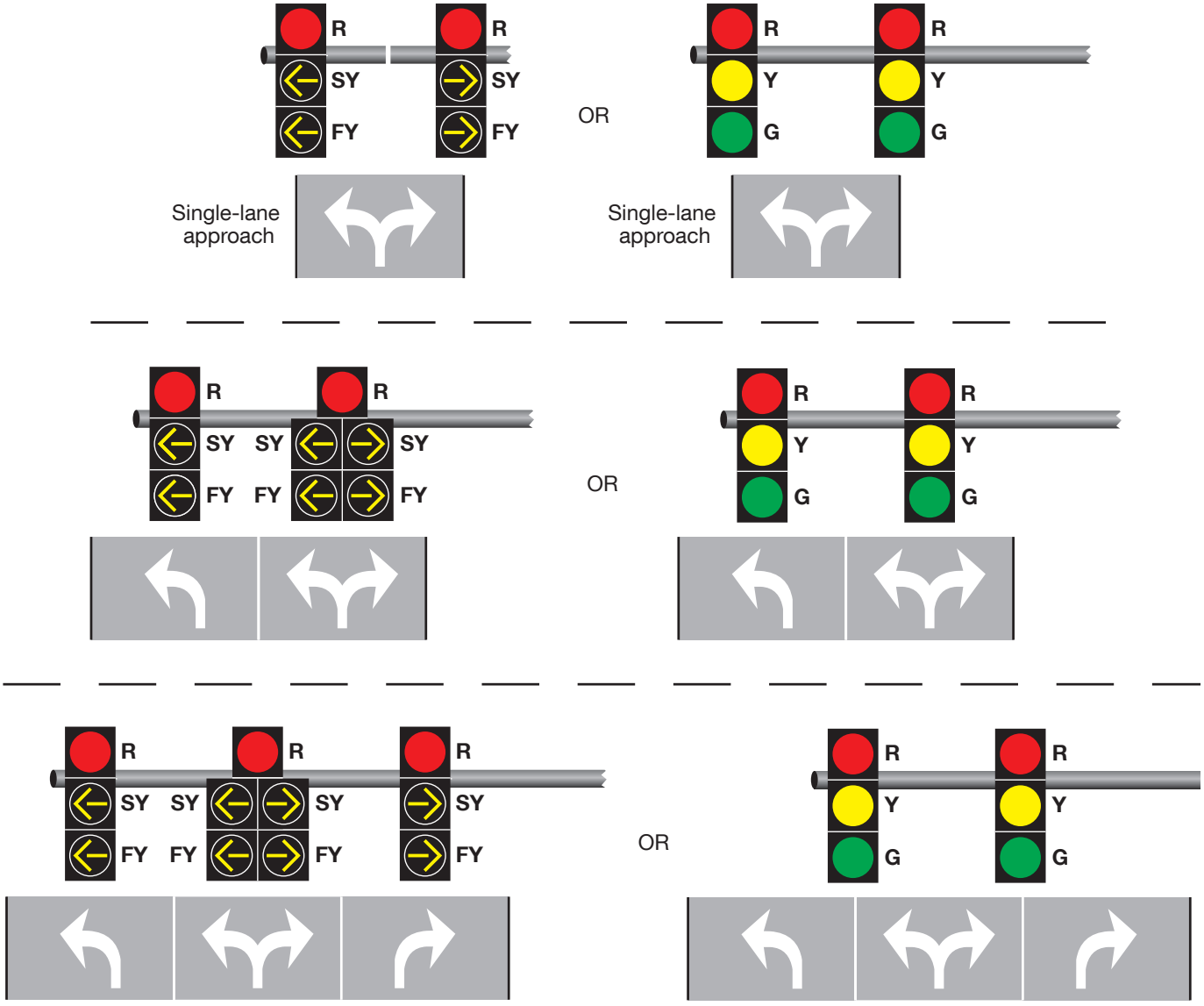
Notes:

1. A conflict with the right-turn movement is illustrated.
2. Horizontally-aligned signal faces may also be used.
3. Shared signal faces may also be 5 sections in a vertical straight line instead of a cluster.

*Left-turn GREEN ARROW section shall be included if there is an opposing one-way approach and the signal phasing eliminates conflicts.

Figure 4F-15. Signal Indications for Approaches with Combined Left-Turn/Right-Turn Lane and No Through Movement (Sheet 3 of 3)

C – Pedestrian or vehicular conflicts with both turn movements



Notes:

1. Horizontally-aligned signal faces may also be used.
2. Shared signal faces may also be 5 sections in a vertical straight line instead of a cluster.

Section 4F.17 Yellow Change and Red Clearance Intervals

Support:

01 The exclusive function of the yellow change interval is to warn traffic approaching a signalized location that their permission to proceed is being terminated after which they will be directed to stop, or in the case of a protected/permissive turning movement that their protected movement is being terminated after which they will need to perform their turn in a permissive manner.

Standard:

02 **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.**

03 **The duration of the yellow change interval shall be determined using engineering practices.**

Support:

04 Section 4F.01 contains provisions regarding the display of steady CIRCULAR YELLOW signal indications to approaches from which drivers are allowed to make permissive left turns.

Guidance:

05 *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:

06 **When used, the duration of the red clearance interval shall be determined using engineering practices.**

07 **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.**

08 **The duration of a yellow change interval shall not vary on a cycle-by-cycle basis within the same signal timing plan.**

09 **Except as provided in Paragraph 10 of this Section, 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:

10 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.

11 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.

12 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:

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

Standard:

14 **Except for Warning Beacons mounted on advance warning signs on the approach to a signalized location (see Section 2C.35), 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:

15 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.

Section 4F.18 Preemption and Priority Control of Traffic Control Signals – General

Option:

01 Traffic control signals may be designed and operated to respond to certain classes of approaching vehicles by altering the normal signal timing and phasing plan(s) during the approach and passage of those vehicles. The alternative plan(s) may be as simple as extending a currently displayed green interval or as complex as replacing the entire set of signal phases and timing.

Support:

02 Some types or classes of vehicles supersede others when a traffic control signal responds to more than one type or class. In general, a vehicle that is more difficult to control supersedes a vehicle that is easier to control.

03 Additional information on preemption at highway rail grade crossings can be found in the Texas Department of Transportation Form 2304, "Guide for Determining Time Requirements for Traffic Signal Preemption at Highway-Rail Grade Crossings".

Option:

04 Preemption or priority control of traffic control signals may also be a means of indicating to specified classes of vehicles at certain non-intersection locations, such as on approaches to one-lane bridges and tunnels, movable bridges, highway maintenance and construction activities, metered freeway entrance ramps, and transit operations, that they are permitted to proceed.

Guidance:

05 *When a traffic control signal that is returning to a steady mode from a dark mode (typically upon restoration from a power failure) receives a preemption or priority request, care should be exercised to minimize the possibility of vehicles or pedestrians being misdirected into a conflict with the vehicle making the request.*

Option:

06 During the change from a dark mode to a steady mode under a preemption or priority request, the display of signal indications that could misdirect road users may be prevented by one or more of the following methods:

A. Having the traffic control signal remain in the dark mode,
B. Having the traffic control signal remain in the flashing mode,
C. Altering the flashing mode,
D. Executing the normal start-up routine before responding, or
E. Responding directly to initial or dwell period.

Guidance:

07 *Traffic control signals operating under preemption control or under priority control should be operated in a manner designed to keep traffic moving.*

08 *Traffic control signals that are designed to respond under preemption or priority control to more than one type or class of vehicle should be designed to respond in the relative order of importance or difficulty in stopping the type or class of vehicle. The order of priority should be: train, boat, heavy vehicle (fire vehicle, emergency medical service), light vehicle (law enforcement), light rail transit, rubber-tired transit.*

Option:

09 If engineering judgment indicates that light rail transit signal indications would reduce road user confusion that might otherwise occur if standard traffic signal indications were used to control these movements, light rail transit signal indications complying with Section 8D.15 and as illustrated in Figure 8D-3 may be used for preemption or priority control of the following exclusive movements at signalized intersections:

A. Public transit buses in "queue jumper" lanes, and
B. Public transit buses in semi-exclusive or mixed-use alignments.

Section 4F.19 Preemption Control of Traffic Control Signals

Support:

01 Preemption control (see definition in Section 1C.02) is typically given to trains, boats, emergency vehicles, and light rail transit.

02 Examples of preemption control include the following:

A. The prompt displaying of green signal indications at signalized locations ahead of fire vehicles, law enforcement vehicles, ambulances, and other official emergency vehicles;

B. A special sequence of signal phases and timing to expedite and/or provide additional clearance time for vehicles to clear the tracks prior to the arrival of rail traffic; and

C. A special sequence of signal phases to display a steady red indication to prohibit turning movements toward the tracks during the approach or passage of rail traffic.

Standard:

03 **During the transition into preemption control, the yellow change interval, and any red clearance interval that follows, shall not be shortened or omitted.**

Option:

04 During the transition into preemption control:

A. Any pedestrian walk interval and/or pedestrian change interval may be shortened or omitted only when the traffic control signal is being preempted because a boat is approaching a movable bridge or because rail traffic is approaching a grade crossing.

B. The red clearance interval, if any, may be omitted so that the return to the previous green signal indication follows a steady yellow signal indication in the same signal face.

Standard:

05 **During preemption control and during the transition out of preemption control:**

A. Any yellow change interval, and any red clearance interval that follows, shall not be shortened or omitted.

B. A signal indication sequence from a steady yellow signal indication to a green signal indication shall not be permitted.

Option:

06 A distinctive indication may be provided at the intersection to inform law enforcement personnel who are escorting traffic (such as a parade or funeral procession) that the traffic control signal has changed to a red indication not because of normal cycling, but because it has been preempted by rail traffic approaching an adjacent grade crossing or by boat traffic approaching an adjacent movable bridge.

07 A distinctive indication may be provided at the intersection to show that an emergency vehicle has been given control of the traffic control signal (see Section 11-106 of the "Uniform Vehicle Code"). In order to assist in the understanding of the control of the traffic control signal, a common distinctive indication may be used where drivers from different agencies travel through the same intersection when responding to emergencies.

Guidance:

08 *Except for traffic control signals interconnected with light rail transit systems, traffic control signals with railroad preemption or coordinated with flashing-light signal systems should be provided with a back-up power supply.*

09 *If a traffic control signal or hybrid beacon is installed near or within a grade crossing or if a grade crossing with active traffic control devices is within or near a signalized highway intersection, Chapter 8D should be consulted.*

Support:

10 Section 8D.09 contains additional information regarding preemption for grade crossings. Section 8D.10 contains information regarding prohibiting movements toward the grade crossing during preemption. Sections 8D.11 and 8D.12 contain additional information regarding pre-signals and queue cutter signals, respectively, for grade crossings.

11 Additional information on preemption at highway rail grade crossings can be found in the Texas Department of Transportation Form 2304, "Guide for Determining Time Requirements for Traffic Signal Preemption at Highway-Rail Grade Crossings".

Section 4F.20 Priority Control of Traffic Control Signals

Support:

01 Priority control (see definition in Section 1C.02) is typically given to certain non-emergency vehicles such as light-rail transit vehicles operating in a mixed-use alignment and buses.

02 Examples of priority control include the following:

A. The displaying of early or extended green signal indications at an intersection to assist public transit vehicles improve operations, and

B. Special phasing to assist public transit vehicles in entering the travel stream ahead of other waiting traffic.

Standard:

03 **During priority control and during the transition into or out of priority control:**

A. The shortening or omission of any yellow change interval, and of any red clearance interval that follows, shall not be permitted.

B. The shortening of any pedestrian walk interval below that time described in Section 4I.06 shall not be permitted.

C. The omission of a pedestrian walk interval and its associated change interval shall not be permitted unless the associated vehicular phase is also omitted or the pedestrian phase is exclusive.

D. The shortening or omission of any pedestrian change interval shall not be permitted.

E. A signal indication sequence from a steady yellow signal indication to a green signal indication shall not be permitted.

CHAPTER 4G. FLASHING OPERATION OF TRAFFIC CONTROL SIGNALS

Section 4G.01 Flashing Operation of Traffic Control Signals – General

Standard:

01 **The light source of a flashing signal indication shall be flashed continuously at a rate of not less than 50 or more than 60 times per minute.**

02 **The displayed period of each flash shall be a minimum of ½ and a maximum of ⅔ of the total flash cycle.**

03 **Flashing signal indications shall comply with the requirements of other Sections of this Manual regarding visibility limiting or positioning of conflicting signal indications, except that flashing yellow signal indications for through traffic shall not be required to be visibility limited or positioned to minimize visual conflict for road users in separately-controlled turn lanes.**

04 **Each traffic control signal shall be provided with an independent flasher mechanism that operates in compliance with this Chapter.**

05 **A manual switch shall be provided to initiate the flashing mode. A conflict monitor (malfunction management unit) circuit and, if appropriate, an automatic means shall also be provided to initiate the flashing mode.**

06 **The flashing operation shall not be terminated by removing or turning off the controller unit or the conflict monitor (malfunction management unit) or both.**

Option:

07 Based on engineering study or engineering judgment, traffic control signals may be operated in the flashing mode on a scheduled basis during one or more periods of the day rather than operated continuously in the steady (stop-and-go) mode.

Support:

08 Sections 4I.06 and 4K.04 contain information regarding the operation of pedestrian signal heads and accessible pedestrian signal detector push button locator tones, respectively, during flashing operation.

Section 4G.02 Flashing Operation – Transition into Flashing Mode

Option:

01 The transition from steady (stop-and-go) mode to flashing mode, if initiated by a conflict monitor (malfunction management unit) or by a manual switch, may be made at any time.

Standard:

02 **Programmed changes from steady (stop-and-go) mode to flashing mode shall be made under either of the following circumstances:**

- **A. At the end of the common major-street red interval (such as just prior to the start of the green in both directions on the major street), or**
- **B. Directly from a CIRCULAR GREEN signal indication to a flashing CIRCULAR YELLOW signal indication, or from a GREEN ARROW signal indication to a flashing YELLOW ARROW signal indication, or from a flashing YELLOW ARROW signal indication (see Sections 4F.02, 4F.04, 4F.08, 4F.09, 4F.11, and 4F.15) to a flashing YELLOW ARROW signal indication (in a different signal section if the signal face displays the steady YELLOW ARROW signal indication in a different section than the flashing YELLOW ARROW signal indication).**

03 **During programmed changes into flashing mode, no green signal indication or flashing yellow signal indication shall be terminated and immediately followed by a steady red or flashing red signal indication without first displaying the steady yellow signal indication.**

Section 4G.03 Flashing Operation – Signal Indications during Flashing Mode

Guidance:

01 *When a traffic control signal is operated in the flashing mode, a flashing yellow signal indication should be used for the major street and a flashing red signal indication should be used for the other approaches unless flashing red signal indications are used on all approaches.*

Standard:

02 **When a traffic control signal is operated in the flashing mode, all of the green signal indications at the signalized location shall be dark (non-illuminated) and shall not be displayed in either a steady or**

flashing manner, except for single-section GREEN ARROW signal indications as provided in Paragraph 6 of this Section.

03 **Flashing yellow signal indications shall be used on more than one approach to a signalized location only if those approaches do not conflict with each other.**

04 **Except as provided in Paragraph 5 of this Section, when a traffic control signal is operated in the flashing mode, one and only one signal indication in every signal face at the signalized location shall be flashed.**

Option:

05 If a signal face has two identical CIRCULAR RED or RED ARROW signal indications (see Section 4E.04), both of those identical signal indications may be flashed simultaneously.

Standard:

06 **No steady indications, other than a single-section signal face consisting of a continuously-displayed GREEN ARROW signal indication that is used alone to indicate a continuous movement in the steady (stop-and-go) mode, shall be displayed at the signalized location during the flashing mode. A single-section GREEN ARROW signal indication shall remain continuously displayed when the traffic control signal is operated in the flashing mode.**

07 **If a signal face includes both circular and arrow signal indications of the color that is to be flashed, only the circular signal indication shall be flashed.**

08 **All signal faces that are flashed on an approach shall flash the same color, either yellow or red, except that separate turn signal faces (see Sections 4F.04, 4F.06, 4F.08, 4F.11, 4F.13, and 4F.15) shall be permitted to flash a RED ARROW signal indication when the adjacent through movement signal indications are flashed yellow. Shared signal faces (see Sections 4F.03, 4F.05, 4F.07, 4F.10, 4F.12, and 4F.14) for turn movements shall not be permitted to flash a CIRCULAR RED signal indication when the adjacent through movement signal indications are flashed yellow.**

09 **The appropriate RED ARROW or YELLOW ARROW signal indication shall be flashed when a signal face consists entirely of arrow indications. A signal face that consists entirely of arrow indications and that provides a protected only turn movement during the steady (stop-and-go) mode or that provides a flashing yellow arrow or flashing red arrow signal indication for a permissive turn movement during the steady (stop-and-go) mode shall be permitted to flash the YELLOW ARROW signal indication during the flashing mode if the adjacent through movement signal indications are flashed yellow and if it is intended that a permissive turn movement not requiring a full stop by each turning vehicle be provided during the flashing mode.**

Support:

10 The mode of operation of bicycle signal faces during flashing operations are subject to the requirements of Section 4H.05.

Section 4G.04 Flashing Operation – Transition Out of Flashing Mode

Standard:

01 **All changes from flashing mode to steady (stop-and-go) mode shall be made under one of the following procedures:**

- **A. Yellow-red flashing mode: Changes from flashing mode to steady (stop-and-go) mode shall be made at the beginning of the major-street green interval (when a green signal indication is displayed to through traffic in both directions on the major street), or if there is no common major-street green interval, at the beginning of the green interval for the major traffic movement on the major street.**
- **B. Red-red flashing mode: Changes from flashing mode to steady (stop-and-go) mode shall be made by changing the flashing red indications to steady red indications followed by appropriate green indications to begin the steady mode cycle. These green indications shall be the beginning of the major-street green interval (when a green signal indication is displayed to through traffic in both directions on the major street) or if there is no common major-street green interval, at the beginning of the green interval for the major traffic movement on the major street.**

Guidance:

02 *The steady red clearance interval provided during the change from red-red flashing mode to steady (stop-and-go) mode should have a minimum duration of 6 seconds.*

03 *When changing from the yellow-red flashing mode to steady (stop-and-go) mode at a location where there is a common major-street green interval, the flashing red signal indications for the minor street should*

immediately change to steady red signal indications, and the flashing yellow signal indications for the through movements on the major street should change to green signal indications in both directions (after the minor-street signal indications have been steady red for a short time, if desired), or the flashing yellow signal indications for the through movements on the major street should change to steady yellow signal indications followed by a steady red clearance interval before changing to green signal indications in both directions.

04 *When changing from the yellow-red flashing mode to steady (stop-and-go) mode at a location where there is no common major-street green interval, the flashing red signal indications for the minor street should immediately change to steady red signal indications, and the flashing yellow signal indications for the through movements on the major street should change to steady yellow signal indications followed by a steady red clearance interval before changing to green signal indications for the major traffic movement on the major street.*

Standard:

05 **During programmed changes out of flashing mode, no flashing yellow signal indication shall be terminated and immediately followed by a steady red or flashing red signal indication without first displaying a steady yellow signal indication.**

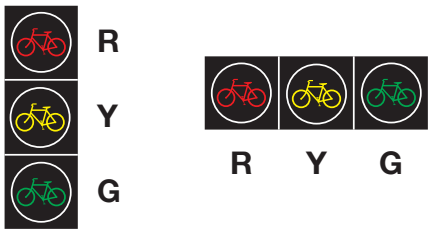
Option:

06 Because special midblock signals that rest in flashing circular yellow in the position normally occupied by the green signal indication do not have a green signal indication in the signal face, these signals may go directly from flashing circular yellow (in the position normally occupied by the green signal indication) to steady yellow without going first to a green signal indication.

CHAPTER 4H. BICYCLE SIGNALS

Section 4H.01 Use of Bicycle Signal Faces

Figure 4H-1. Typical Arrangements of Bicycle Signal Faces



Option:

01 A bicycle signal face may be used to provide separate control of a bicyclist movement for various situations, including the following:

A. To provide a protected bicycle signal phase or a leading or lagging bicycle interval;

B. To continue a through bicycle lane on the right-hand side of a mandatory right-turn lane (or on the left-hand side of a mandatory left-turn lane) that would otherwise be in non-compliance with Paragraph 1 of Section 9E.02 or Paragraph 7 of Section 9E.06;

C. To provide a bicycle interval for a counter-flow bicycle facility; or

D. To provide for unusual or unexpected arrangements of the bicyclist movement through complex intersections, conflict areas, or signal control.

02 A bicycle signal face may be used at a mid-block traffic control signal where there are no motor vehicle movements parallel to the bicycle crossing.

Support:

03 Chapter 4C contains information on warrants for the installation of a new traffic control signal.

Guidance:

04 *The decision as to whether to incorporate a bicycle signal face(s) into a new traffic control signal design should be made during the engineering study performed in accordance with Paragraph 1 of Section 4C.01.*

05 *Engineering judgment should be exercised in determining whether or not it would be advantageous or beneficial to install a bicycle signal face(s) at an existing traffic control signal.*

Support:

06 Retrofitting existing circular traffic signals that are operated as bicycle signal faces with bicycle symbol signal faces is analogous to retrofitting existing traffic signals with pedestrian signals where such a determination is not required through an engineering study.

07 For the purpose of warrant analyses, provisions for classifying bicycles are provided in Paragraph 16 of Section 4C.01 and Paragraph 2 of Section 9F.01.

Standard:

08 **If used, a bicycle signal face shall only be used to control bicyclist movements from a designated bicycle lane or from a separate facility, such as a shared-use path.**

09 **If used, a bicycle signal face shall only be used to control bicyclist movements where bicyclists moving on a GREEN BICYCLE or YELLOW BICYCLE signal indication are not in conflict with any simultaneous motor vehicle movement at the signalized location, including right (or left) turns on red.**

Guidance:

10 *If used where motor vehicle traffic can make the same movements as bicyclists, a bicycle signal face should only be used if the bicyclist movement controlled by the bicycle signal face is sometimes allowed to proceed or sometimes required to stop at times when motor vehicle traffic, making the same movement and controlled by other vehicular signal faces, is required to stop or allowed to proceed, respectively.*

Section 4H.02 Prohibited Uses of Bicycle Signal Faces

Standard:

Rev. 1

01 **Bicycle signal faces shall not be used to allow conflicting bicyclist movements from perpendicular or nearly perpendicular directions to enter the intersection at the same time.**

02 **Bicycle signal faces shall not be used for controlling any bicyclist movement that is sharing an approach lane with motor vehicle traffic.**

03 **Bicycle signal faces shall not be used in any manner with respect to the design and operation of a hybrid beacon.**

Section 4H.03 Bicycle Signal Signs

Support:

01 The primary purposes of the Bicycle Signal (R10-40, R10-40a, R10-41, R10-41a, R10-41b) sign (see Section 9B.22) are to inform road users that the signal indications in the bicycle signal face are intended only for bicyclists, and to inform bicyclists which specific bicyclist movements are controlled by the bicycle signal face.

Standard:

02 **Except as provided in Paragraph 3 of this Section, a Bicycle Signal (R10-40, R10-40a, R10-41, R10-41a, R10-41b, or R10-41c) sign shall be installed immediately adjacent to (including above or below) every bicycle signal face. The Bicycle Signal sign shall have a minimum size of 24 inches x 36 inches if it is placed next to an overhead-mounted bicycle signal face and shall have a minimum size of 12 inches x 21 inches if it is placed next to a post-mounted bicycle signal face.** Rev. 1

Option:

03 The Bicycle Signal sign may be omitted adjacent to a supplemental near-side bicycle signal face containing 4-inch indications.

Section 4H.04 Application of Bicycle Symbol Signal Indications during Steady (Stop-and-Go) Operation

Standard:

01 **Steady bicycle symbol signal indications shall be applied as follows:**

- **A. A steady RED BICYCLE signal indication shall be displayed when it is intended to prohibit bicyclists in a designated bicycle lane or from a separate facility such as a shared-use path from entering the intersection or other controlled area. Turning after stopping shall be permitted as stated in Item C in Paragraph 1 of Section 4A.05.**
- **B. A steady YELLOW BICYCLE signal indication shall be displayed following a GREEN BICYCLE signal indication in the same bicycle signal face. A YELLOW BICYCLE signal indication shall not be displayed in conjunction with the change from the RED BICYCLE signal indication to a GREEN BICYCLE signal indication. The YELLOW BICYCLE signal indication shall be followed by a RED BICYCLE signal indication.**
- **C. A steady GREEN BICYCLE signal indication shall be displayed only when it is intended to permit bicyclists in a designated bicycle lane or from a separate facility such as a shared-use path to enter the intersection as discussed in Section 4A.05.**

Section 4H.05 Application of Bicycle Symbol Signal Indications during Flashing Operation

Standard:

01 **The mode of operation of the bicycle signal faces at a traffic control signal shall be the same as the mode of operation of the other traffic signal faces at the same signalized location. Bicycle signal faces shall operate in the steady (stop-and-go) mode when the other traffic signal faces are operating in the steady (stop-and-go) mode. Bicycle signal faces shall operate in the flashing mode when the other signal faces are operating in the flashing mode. Bicycle signal faces shall not be placed in a dark mode when other vehicular traffic signal faces are operating in the flashing mode.**

Guidance:

02 *When a traffic control signal is operated in the flashing mode, bicycle signal faces should display a flashing RED BICYCLE signal indication if the other vehicular signal faces on the same approach are displaying flashing red signal indications or if there are no other vehicular signal faces on the same approach.*

03 *When a traffic control signal is operated in the flashing mode, bicycle signal faces should display a flashing YELLOW BICYCLE signal indication if the other vehicular signal faces for the through lanes on the same approach are displaying flashing yellow signal indications unless it is determined by engineering judgment that a flashing RED BICYCLE signal indication would provide a safer operation.*

Standard:

04 **A flashing YELLOW BICYCLE and flashing RED BICYCLE signal indication shall be used only if the traffic control signal is being operated in the flashing mode.**

Section 4H.06 Layout of Bicycle Signal Faces

Standard:

01 **Bicycle signal faces shall consist of all bicycle symbol signal indications (see Figure 4H-1). Circular or arrow signal indications shall not be used in a bicycle signal face.**

Option:

02 Bicycle signal faces may be oriented vertically or horizontally.

Standard:

03 **The layouts and arrangements of the bicycle signal face shall be in accordance with the following provisions:**

- **A. Only the bicycle symbol shown on Page 6-7 in the Standard Highway Sign Designs for Texas publication (see Section 1A.05) shall be used for bicycle symbol signal indications and shall be proportioned to fit within the signal lens. The bicycle symbol shall only be positioned horizontally and shall face to the left.**
- **B. The RED BICYCLE, YELLOW BICYCLE, and GREEN BICYCLE signal indications shall be in the same relative position to each other as specified for the CIRCULAR RED, CIRCULAR YELLOW, and CIRCULAR GREEN signal indications, respectively, in Sections 4E.04 and 4E.05.**
- **C. As a specific exception to Paragraph 5 of Section 4E.04, two YELLOW BICYCLE signal indications or two GREEN BICYCLE signal indications shall not be arranged horizontally adjacent to each other at right angles to the basic straight line arrangement to form a clustered signal face.**

Option:

04 Backplates (see Paragraphs 18 and 19 in Section 4D.06) may be used with bicycle signal faces.

05 If a bicycle signal face having 4-inch signal indications is used, the accompanying visors may be omitted.

Section 4H.07 Size of Bicycle Symbol Signal Indications

Standard:

01 **There shall be three nominal diameter sizes for bicycle signal indications: 4 inches, 8 inches, and 12 inches.**

02 **All signal indications in a bicycle signal face shall be of the same size.**

03 **Four-inch signal indications shall not be used for any bicycle signal face other than a supplemental, post-mounted, near-side bicycle signal face.**

Section 4H.08 Placement of Bicycle Signal Faces

Standard:

01 **The provisions of Sections 4D.05 through 4D.08 shall apply to the placement of the bicycle signal faces except as follows:**

- **A. As a specific exception to Item A in Paragraph 1 of Section 4D.05, a minimum of one primary bicycle signal face shall be provided to control traffic for the bicyclist movement, even if a bicyclist through movement exists.**
- **B. The primary bicycle signal face shall have either 8-inch or 12-inch signal indications, even if it is located at the near side of the signal-controlled location.**
- **C. When the primary bicycle signal face is located more than 120 feet beyond the stop line, a supplemental near-side bicycle signal face shall be provided.**

Guidance:

02 *When the primary bicycle signal face is located more than 80 feet and up to 120 feet beyond the stop line, a supplemental near-side bicycle signal face should be provided.*

03 *A bicycle signal face should be separated horizontally or vertically from the nearest vehicular traffic signal face for the same approach by at least 3 feet measured either horizontally perpendicular to the approach between the centers of the signal faces or vertically from the center of the lowest signal indication of the top signal face to the center of the highest signal indication of the bottom signal face. If horizontally-arranged or clustered signal faces are used, the minimum 3-foot horizontal separation between the two signal faces should be measured from the center of the right-most signal indication in the signal face on the left to the center of the left-most signal indication in the signal face on the right.*

04 *Bicycle signal faces should be placed such that visibility is maximized for bicyclists and minimized for adjacent or conflicting vehicle movements not controlled by the bicycle signal face. Consideration should be*

given to using visibility-limited bicycle signal faces in situations where drivers not controlled by the bicycle signal face might be confused by viewing the bicycle signal indications, such as when the bicyclist movement controlled by the bicycle signal face is sometimes allowed to proceed or sometimes required to stop at times when motor vehicle traffic, making the same movement and controlled by other vehicular signal faces, is required to stop or allowed to proceed, respectively.

Section 4H.09 Mounting Height of Bicycle Signal Faces

Standard:

01 **The provisions of Section 4D.09 shall apply to the mounting height of bicycle signal faces except as follows:**

A. The bottom of the signal housing (including brackets) of a bicycle signal face that is not located over a roadway or shoulder shall be a minimum of 7 feet above the sidewalk or ground, and

B. If 4-inch signal indications are used in a supplemental, post-mounted, near-side bicycle signal face, the bottom of the signal housing (including brackets) shall be a minimum of 4 feet and a maximum of 8 feet above the sidewalk or ground. Bicycle signal faces with 4-inch signal indications installed above a pedestrian sidewalk or pathway shall not project more than 4 inches into the pedestrian facility.

Section 4H.10 Intensity and Light Distribution of Bicycle Signal Faces

Guidance:

01 *Except for the 4-inch nominal size of the lens diameter, the intensity and distribution of light from each illuminated bicycle signal face should be similar to that recommended for vehicular traffic signal faces in accordance with Paragraph 11 of Section 4E.01 to the extent practical.*

Section 4H.11 Yellow Change and Red Clearance Intervals for Bicycle Signal Faces

Standard:

01 **The provisions of Section 4F.17 shall apply to the duration of the yellow change and the red clearance intervals of a bicycle signal phase.**

Guidance:

02 *The minimum duration of the yellow change interval of a bicycle signal phase should be 3 seconds.*

Support:

03 The function of the yellow change interval is to warn bicyclists approaching a signalized location that their permission to proceed is being terminated after which they will be directed to stop. Providing clearance time for a bicyclist to travel through the intersection or conflict area is the purpose of the red clearance interval rather than the yellow change interval.

Section 4H.12 Bicycle Push Buttons

Option:

01 Bicycle push buttons may be used for bicycle detection.

Support:

02 The location of bicycle push buttons intended only for use by bicyclists and not pedestrians are determined by engineering judgment considering a reasonable reach without requiring most bicyclists to dismount.

Standard:

03 **Where used, push buttons intended to be used by both pedestrians and bicyclists shall be located and operated to meet all accessibility requirements (see Section 4I.05).**

04 **Bicycle push buttons shall be accompanied by an appropriate regulatory sign (R10-4, R10-24, or R10-26) explaining the purpose and operation of the push button (see Sections 2B.58 and 9B.20).**

CHAPTER 4I. PEDESTRIAN CONTROL FEATURES

Section 4I.01 Pedestrian Signal Heads

Support:

01 Pedestrian signal heads provide special types of traffic signal indications exclusively intended for controlling pedestrians. These signal indications consist of the illuminated symbols of a WALKING PERSON (symbolizing WALK) and an UPRAISED HAND (symbolizing DONT WALK).

02 Section 4D.02 contains information on when to use pedestrian signal heads.

03 Accessible pedestrians signals (see Chapter 4K) where pedestrian signal heads are used provide information in non-visual formats (such as audible tones and/or speech messages, and vibrating surfaces) so that a pedestrian with vision disabilities can know when to cross the street.

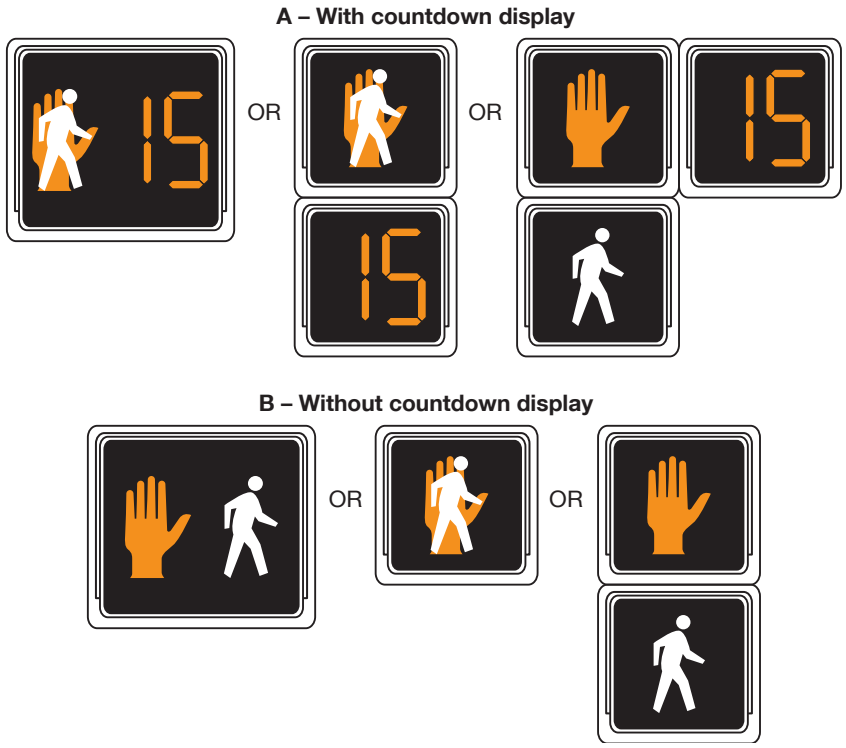
04 Chapter 4J contains information regarding the use of pedestrian hybrid beacons and Chapter 4U contains information regarding the use of In-Roadway Warning Lights at unsignalized marked crosswalks.

Section 4I.02 Size, Design, and Illumination of Pedestrian Signal Head Indications

Standard:

01 **All new pedestrian signal head indications shall be displayed within a rectangular background and shall consist of symbolized messages (see Figure 4I-1), except that existing pedestrian signal head indications with lettered or outline style symbol messages shall be permitted to be retained for the remainder of their useful service life. The symbol designs that are set forth in the "Standard Highway Sign Designs for Texas" publication (see Section 1A.05) shall be used. Each pedestrian signal head indication shall be independently displayed and emit a single color.**

Figure 4I-1. Typical Pedestrian Signal Indications



02 **If a two-section pedestrian signal head is used, the UPRAISED HAND (symbolizing DONT WALK) signal section shall be mounted directly above the WALKING PERSON (symbolizing WALK) signal section. If a one-section pedestrian signal head is used, the symbols shall be either overlaid upon each other or arranged side-by-side with the UPRAISED HAND symbol to the left of the WALKING PERSON symbol, and a light source that can display each symbol independently shall be used.**

03 **The WALKING PERSON (symbolizing WALK) signal indication shall be white, with all except the symbol obscured by an opaque material for signal optical units that use incandescent lamps within optical assemblies that include lenses. The UPRAISED HAND (symbolizing DONT WALK) signal indication shall be Portland orange, with all except the symbol obscured by an opaque material for signal optical units that use incandescent lamps within optical assemblies that include lenses.**

04 **Except as provided in Paragraph 5 of this Section, the requirements of Chapter 3 of the publication entitled "Equipment and Materials Standards of the Institute of Transportation Engineers," 2008, ITE, that pertain to the aspects of the pedestrian signal head design that affect the display of the signal indications shall be met for signal optical units that use incandescent lamps within optical assemblies that include lenses. Except as provided in Paragraph 5 of this Section, the requirements of the publication**

entitled "Pedestrian Traffic Control Signal Indicators – Light Emitting Diode (LED) Signal Modules," 2011, ITE, that pertain to the aspects of the signal head design that affect the display of the signal indications shall be met for light-emitting diode (LED) pedestrian signal head modules.

Guidance:

05 *The intensity and distribution of light from each illuminated pedestrian signal lens or LED pedestrian signal head module should comply with the publications specified in Paragraph 4 of this Section, as appropriate.*

06 *When not illuminated, the WALKING PERSON (symbolizing WALK) and UPRAISED HAND (symbolizing DONT WALK) symbols should not be visible to pedestrians at the far end of the crosswalk that the pedestrian signal head indications control.*

Standard:

07 **For pedestrian signal head indications, the symbols shall be at least 6 inches high.**

08 **The light source of a flashing UPRAISED HAND (symbolizing DONT WALK) signal indication shall be flashed continuously at a rate of not less than 50 or more than 60 times per minute. The displayed period of each flash shall be a minimum of ½ and a maximum of ⅔ of the total flash cycle.**

Guidance:

09 *Pedestrian signal head indications should be conspicuous and recognizable to pedestrians at all distances from the beginning of the controlled crosswalk to a point 10 feet from the end of the controlled crosswalk during both day and night.*

10 *For crosswalks where the pedestrian enters the crosswalk more than 100 feet from the pedestrian signal head indications, the symbols should be at least 9 inches high.*

11 *If the pedestrian signal indication is so bright that it causes excessive glare in nighttime conditions, some form of automatic dimming should be used to reduce the brilliance of the signal indication.*

Option:

12 An animated eyes symbol may be added to a pedestrian signal head in order to prompt pedestrians to look for vehicles in the intersection during the time that the WALKING PERSON (symbolizing WALK) signal indication is displayed.

Standard:

13 **If used, the animated eyes symbol shall consist of an outline of a pair of white steadily illuminated eyes with white eyeballs that scan from side to side at a rate of approximately once per second. The animated eyes symbol shall be at least 12 inches wide with each eye having a width of at least 5 inches and a height of at least 2.5 inches. The animated eyes symbol shall be illuminated at the start of the walk interval and shall terminate at the end of the walk interval.**

Section 4I.03 Location and Height of Pedestrian Signal Heads

Standard:

01 **Pedestrian signal heads shall be mounted with the bottom of the signal housing including brackets not less than 7 feet or more than 10 feet above sidewalk level, and shall be positioned and adjusted to provide maximum visibility at the beginning of the controlled sidewalk.**

Guidance:

02 *If pedestrian signal heads are mounted on the same support as vehicular signal heads, there should be a physical separation between them.*

Section 4I.04 Countdown Pedestrian Signals

Standard:

01 **All pedestrian signal heads used at crosswalks where the pedestrian change interval is more than 7 seconds shall include a pedestrian change interval countdown display in order to inform pedestrians of the number of seconds remaining in the pedestrian change interval.**

Option:

02 Pedestrian signal heads used at crosswalks where the pedestrian change interval is 7 seconds or less may include a pedestrian change interval countdown display in order to inform pedestrians of the number of seconds remaining in the pedestrian change interval.

Standard:

03 **Where countdown pedestrian signals are used, the countdown shall always be displayed simultaneously with the flashing UPRAISED HAND (symbolizing DONT WALK) signal indication displayed for that crosswalk.**

04 **Countdown pedestrian signals shall consist of Portland orange numbers that are at least 6 inches in height on a black opaque background. The countdown pedestrian signal shall be located immediately adjacent to the associated UPRAISED HAND (symbolizing DONT WALK) pedestrian signal head indication (see Figure 4I-1).**

05 **The display of the number of remaining seconds shall begin only at the beginning of the pedestrian change interval (flashing UPRAISED HAND). After the countdown displays zero, the display shall remain dark until the beginning of the next countdown.**

06 **The countdown pedestrian signal shall display the number of seconds remaining until the termination of the pedestrian change interval (flashing UPRAISED HAND). Countdown displays shall not be used during the walk interval. Countdown displays shall not be used during the red clearance interval of a concurrent vehicular phase that is ending simultaneously with or after the end of the pedestrian phase.**

Guidance:

07 *If used with a pedestrian signal head that does not have a concurrent vehicular phase, the pedestrian change interval (flashing UPRAISED HAND) should be set to be approximately 4 seconds less than the required pedestrian clearance time (see Section 4I.06) and an additional clearance interval (during which a steady UPRAISED HAND is displayed) should be provided prior to the start of the conflicting vehicular phase.*

08 *For crosswalks where the pedestrian enters the crosswalk more than 100 feet from the countdown pedestrian signal display, the numbers should be at least 9 inches in height.*

09 *Because some technology includes the countdown pedestrian signal logic in a separate timing device that is independent of the timing in the traffic signal controller, care should be exercised by the engineer when timing changes are made to pedestrian change intervals.*

10 *If the pedestrian change interval is interrupted or shortened as a part of a transition into a preemption sequence (see Section 4F.19), the countdown pedestrian signal display should be discontinued and go dark immediately upon activation of the preemption transition.*

Section 4I.05 Pedestrian Detectors

Option:

01 Pedestrian detectors may be push buttons or passive detection devices.

Support:

02 Passive detection devices register the presence of a pedestrian in a position indicative of a desire to cross, without requiring the pedestrian to push a button. Some passive detection devices are capable of tracking the progress of a pedestrian as the pedestrian crosses the roadway for the purpose of extending or shortening the duration of certain pedestrian timing intervals.

03 The provisions in this Section place pedestrian push buttons within easy reach of pedestrians who are intending to cross each crosswalk and make it obvious which push button is associated with each crosswalk. These provisions also position push button poles in optimal locations for installation of accessible pedestrian signals (see Chapter 4K). Information regarding reach ranges can be found in the U.S. Department of Justice 2010 ADA Standards for Accessible Design, September 15, 2010, 28 CFR 35 and 36, Americans with Disabilities Act of 1990.

Guidance:

04 *If pedestrian push buttons are used, they should be capable of easy activation requiring no more than 5 pounds of force, should not require tight grasping, pinching, or twisting of the wrist, and should be conveniently located near each end of the crosswalks. Except as provided in Paragraphs 5 and 6 of this Section, pedestrian push buttons should be located to meet all of the following criteria (see Figure 4I-2):*

- *A. Unobstructed and accessible within one or more of the reach ranges specified in Section 308, and from a clear ground space as specified in Section 305, of the 2010 ADA Standards for Accessible Design;*
- *B. To provide a wheelchair accessible route from the push button to the ramp;*
- *C. On the side of the curb ramp which is farthest from the center of the intersection;*
- *D. Not greater than 10 feet from the edge of the associated curb ramp which is farther from the center of the intersection;*

E. Not greater than 5 feet from the outside edge of the marked crosswalk farthest from the center of the intersection;
F. Not farther from the crosswalk than the stop line is, if present;
G. Between 1.5 and 6 feet from the face of the curb or from the outside edge of the shoulder (or if no shoulder exists, from the edge of the pavement);
H. With the face of the push button parallel to the crosswalk to be used;
I. At a mounting height of approximately 3.5 feet, but no more than 4 feet, above the sidewalk;
J. Allowing a minimum 4-foot continuous clear width for a pedestrian access route; and
K. Outside the flared side of the curb ramp, if present.

05 *Where there are physical constraints that make it impracticable to place the pedestrian push button adjacent to a level all-weather surface, the surface should be as level as feasible.*

06 *Where there are physical constraints that make it impracticable to place the pedestrian push button between 1.5 and 6 feet from the face of the curb or from the outside edge of the shoulder (or if no shoulder exists, from the edge of the pavement), it should not be farther than 10 feet from the face of the curb or from the outside edge of the shoulder (or if no shoulder exists, from the edge of the pavement).*

07 *Except as provided in Paragraph 8 of this Section, where two pedestrian push buttons are provided on the same corner of a signalized location, the push buttons should be separated by a distance of at least 10 feet.*

Option:

08 Where there are physical constraints on a particular corner that make it impracticable to provide the 10-foot separation between the two pedestrian push buttons the push buttons may be placed closer together or on the same pole.

Support:

09 Figure 4I-3 shows typical pedestrian push button locations for a variety of situations.

Standard:

10 **If a pedestrian push button is provided, a sign (see Section 2B.58) shall also be installed adjacent to the pedestrian push button detector explaining the purpose and use.**

Option:

11 At certain locations, a supplemental sign in a more visible location may be used to call attention to the pedestrian push button.

Standard:

12 **The positioning of pedestrian push buttons and the legends on the pedestrian push button signs shall indicate which crosswalk signal is actuated by each pedestrian push button.**

13 **If the pedestrian clearance time is sufficient only to cross from the curb or shoulder to a median of sufficient width for pedestrians to wait and the signals are pedestrian actuated, an additional pedestrian detector shall be provided in the median.**

Guidance:

14 *The use of additional pedestrian detectors on islands or medians where a pedestrian might become stranded should be considered.*

15 *If used, special purpose push buttons (to be operated only by authorized persons) should include a housing capable of being locked to prevent access by the general public and do not need an instructional sign.*

Standard:

16 **If used, a pilot light or other means of indication installed with a pedestrian push button shall not be illuminated until actuation. Once it is actuated, the pilot light shall remain illuminated until the pedestrian's green or WALKING PERSON (symbolizing WALK) signal indication is displayed.**

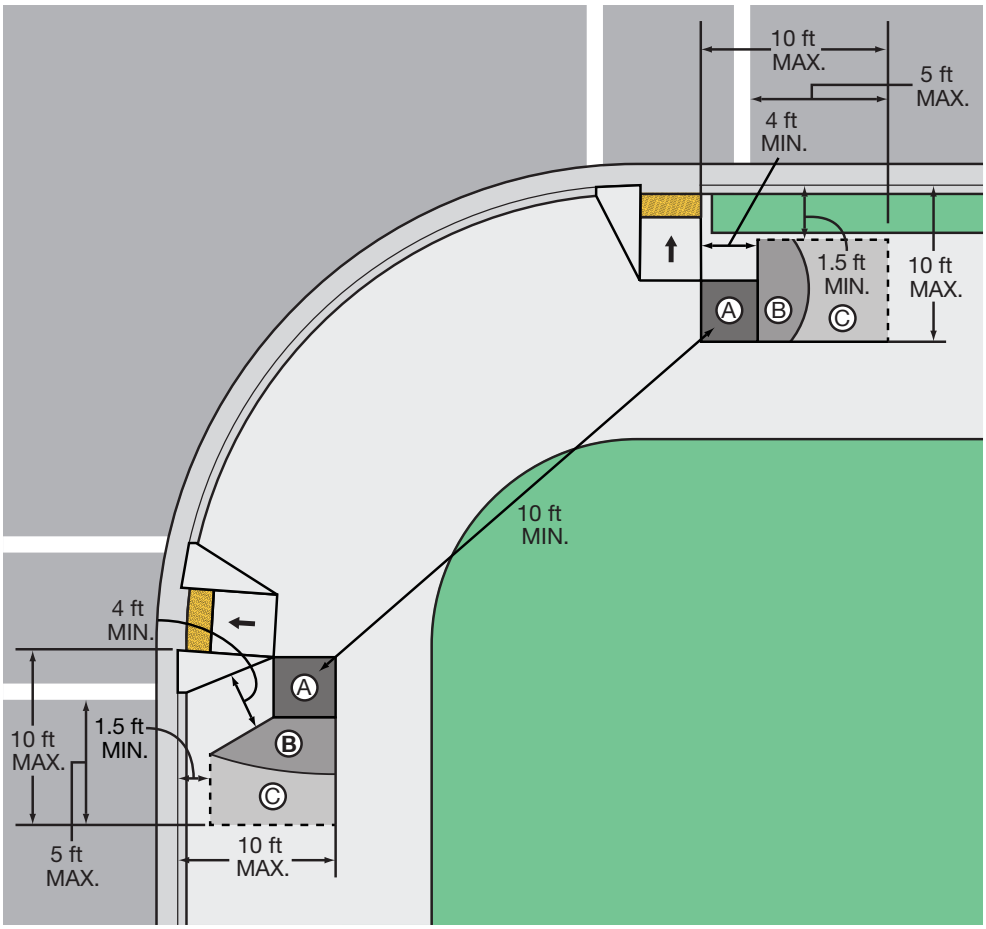
Option:

17 At signalized locations with a demonstrated need and subject to equipment capabilities, pedestrians with special needs may be provided with additional crossing time by means of an extended push button press.

Standard:

18 **If additional crossing time is provided by means of an extended push button press, a PUSH BUTTON FOR 2 SECONDS FOR EXTRA CROSSING TIME (R10-32P) plaque (see Figure 2B-27) shall be installed adjacent to the pedestrian push button detector.**

Figure 4I-2. Preferred Push Button Location Area



Notes:

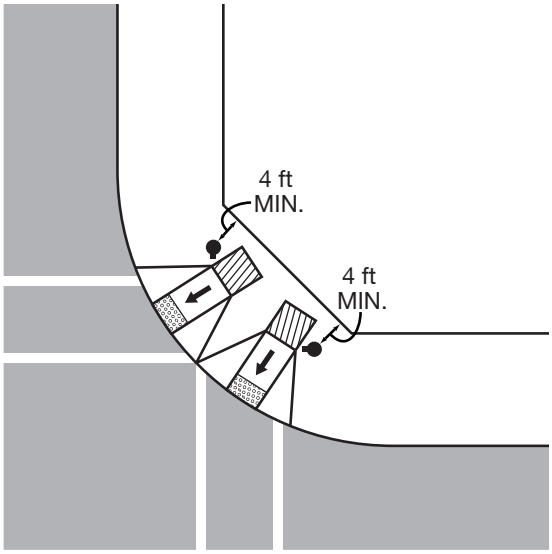
1. The push button detector should be located 5 feet or less from the outside edge of the marked crosswalk farthest from the intersection.
2. The push button detector should be located no farther from the crosswalk than the stop line, if one is present.
3. A 4-foot minimum unobstructed pedestrian access route should be maintained.
4. The maximum (MAX.) and minimum (MIN.) dimensions shown in this figure are recommendations.
5. Two pedestrian push buttons on the same corner should be separated by at least 10 feet. The 10-foot dimension shown in this figure is in reference to the placement of the push buttons within their respective areas.
6. Figure 4I-3 shows typical push button locations.
7. This figure is not drawn to scale.

Legend

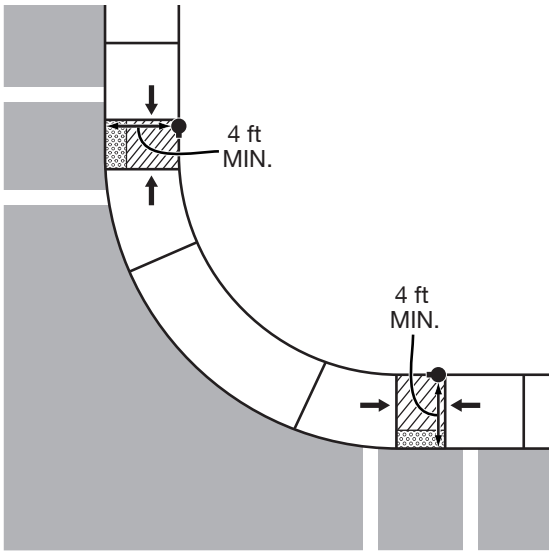
- Downward slope
- (A) Preferred location for push button
- (B) Acceptable location for push button
- (C) Acceptable, but less desirable

Figure 4I-3. Typical Push Button Locations

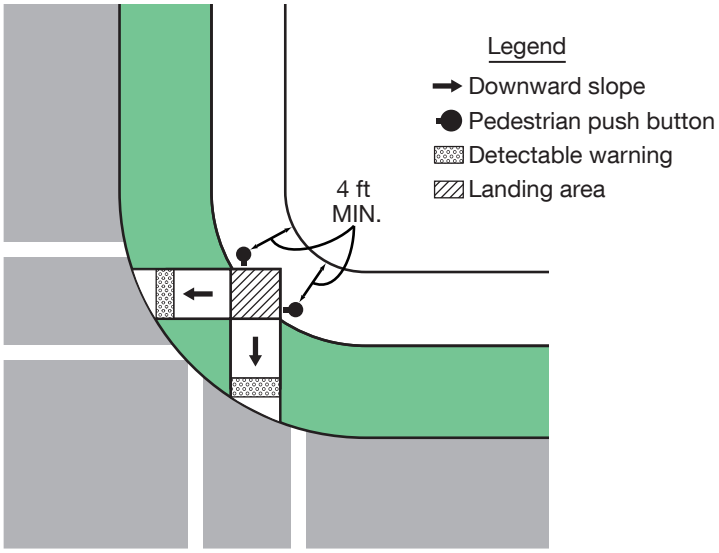
A – Perpendicular curb ramps with crosswalks close together



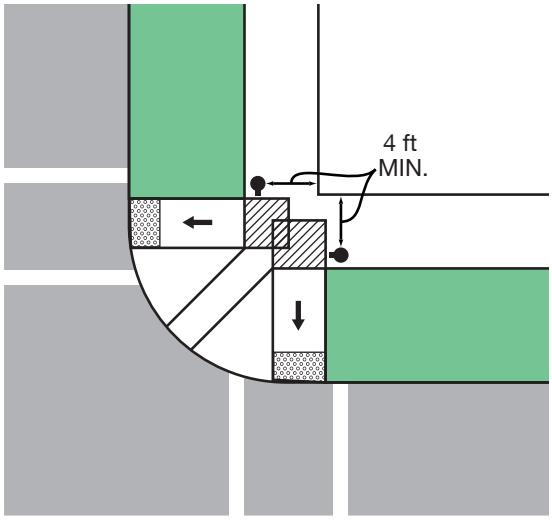
B – Parallel curb ramps



C – Perpendicular curb ramps with shared landing area



D – Perpendicular curb ramps with continuous surface between ramps



Notes:

1. This figure is not drawn to scale.
2. These drawings are intended to describe the typical locations for pedestrian push button installations. They are not intended to be a guide for the design of curb ramps.

Section 4I.06 Pedestrian Intervals and Signal Phases

Standard:

01 **At intersections equipped with pedestrian signal heads, the pedestrian signal indications shall be displayed except when the vehicular traffic control signal is being operated in the flashing mode. At those times, the pedestrian signal indications shall not be displayed.**

02 **Except as provided in Paragraph 3 of Section 4J.03, when the pedestrian signal heads associated with a crosswalk are displaying either a steady WALKING PERSON (symbolizing WALK) or a flashing UPRAISED HAND (symbolizing DONT WALK) signal indication, a steady red signal indication shall be shown to any conflicting vehicular movement that is approaching the intersection or midblock location perpendicular or nearly perpendicular to the crosswalk.**

03 **When pedestrian signal heads are used, a WALKING PERSON (symbolizing WALK) signal indication shall be displayed only when pedestrians are permitted to leave the curb or shoulder.**

04 **A pedestrian change interval consisting of a flashing UPRAISED HAND (symbolizing DONT WALK) signal indication shall begin immediately following the WALKING PERSON (symbolizing WALK) signal indication. Following the pedestrian change interval, a buffer interval consisting of a steady UPRAISED HAND (symbolizing DONT WALK) signal indication shall be displayed for at least 2 seconds prior to the release of any conflicting vehicular movement. The sum of the time of the pedestrian change interval and the buffer interval shall not be less than the calculated pedestrian clearance time (see Paragraphs 7 through 16 of this Section). The buffer interval shall not begin later than the beginning of the red clearance interval, if used.**

Option:

05 During the yellow change interval, the UPRAISED HAND (symbolizing DON'T WALK) signal indication may be displayed as either a flashing indication, a steady indication, or a flashing indication for an initial portion of the yellow change interval and a steady indication for the remainder of the interval.

Support:

06 Figure 4I-4 illustrates the pedestrian intervals and their possible relationships with associated vehicular signal phase intervals.

Guidance:

07 *Except as provided in Paragraph 8 of this Section, the pedestrian clearance time should be sufficient to allow a pedestrian crossing in the crosswalk who left the curb or edge of pavement at the end of the WALKING PERSON (symbolizing WALK) signal indication to travel at a walking speed of 3.5 feet per second to at least the far side of the traveled way or to a median of sufficient width for pedestrians to wait.*

Option:

08 A walking speed of up to 4 feet per second may be used to evaluate the sufficiency of the pedestrian clearance time at locations where an extended push button press function has been installed to provide slower pedestrians an opportunity to request and receive a longer pedestrian clearance time. Passive pedestrian detection may also be used to automatically adjust the pedestrian clearance time based on the pedestrian's actual walking speed or actual clearance of the crosswalk.

09 The additional time provided by an extended push button press to satisfy pedestrian clearance time needs may be added to either the walk interval or the pedestrian change interval.

Guidance:

10 *Where pedestrians who walk slower than 3.5 feet per second, or pedestrians who use wheelchairs, routinely use the crosswalk, a walking speed of less than 3.5 feet per second should be considered in determining the pedestrian clearance time.*

11 *Except as provided in Paragraph 12 of this Section, the walk interval should be at least 7 seconds in length so that pedestrians will have adequate opportunity to leave the curb or shoulder before the pedestrian clearance time begins.*

Option:

12 If pedestrian volumes and characteristics do not require a 7-second walk interval, walk intervals as short as 4 seconds may be used.

Support:

13 The walk interval is intended for pedestrians to start their crossing. The pedestrian clearance time is intended to allow pedestrians who started crossing during the walk interval to complete their crossing. Longer walk

intervals are often used when the duration of the vehicular green phase associated with the pedestrian crossing is long enough to allow it.

Guidance:

14 *The total of the walk interval and pedestrian clearance time should be sufficient to allow a pedestrian crossing in the crosswalk who left the pedestrian detector (or, if no pedestrian detector is present, a location 6 feet behind the face of the curb or 6 feet behind the edge of the pavement) at the beginning of the WALKING PERSON (symbolizing WALK) signal indication to travel at a walking speed of 3 feet per second to the far side of the traveled way being crossed or to the median if a two-stage pedestrian crossing sequence is used. Any additional time that is required to satisfy the conditions of this paragraph should be added to the walk interval.*

Option:

15 On a street with a median of sufficient width for pedestrians to wait, a pedestrian clearance time that allows the pedestrian to cross only from the curb or shoulder to the median may be provided.

Standard:

16 **Where the pedestrian clearance time is sufficient only for crossing from the curb or shoulder to a median of sufficient width for pedestrians to wait, median-mounted pedestrian signals, with pedestrian detectors (see Sections 4I.05 and 4K.01) if actuated operation is used, shall be provided and signing such as the R10-3d sign (see Section 2B.58) shall be provided to notify pedestrians to cross only to the median to await the next WALKING PERSON (symbolizing WALK) signal indication.**

Support:

17 Accessible pedestrian signals (see Chapter 4K) where median-mounted pedestrian signals and detectors are used provide information in non-visual formats (such as audible tones and/or speech messages, and vibrating surfaces) so that a pedestrian with vision disabilities can know when to resume crossing the street after crossing to the median.

Option:

18 During the transition into preemption, the walk interval and the pedestrian change interval may be shortened or omitted as described in Section 4F.19.

19 At intersections with high pedestrian volumes and high conflicting left-turning or right-turning vehicle volumes, a brief leading pedestrian interval, during which an advance WALKING PERSON (symbolizing WALK) indication is displayed for the crosswalk while red indications continue to be displayed to parallel through and/or turning traffic, may be used to reduce conflicts between pedestrians and turning vehicles.

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Support:

20 Accessible pedestrian signals (see Chapter 4K) where leading pedestrian intervals are used provide information in non-visual formats (such as audible tones and/or speech messages, and vibrating surfaces) so that a pedestrian with vision disabilities can know when to cross the street in the absence of the audible cues normally provided when the onset of the vehicular and pedestrian movements coincide.

21 If a leading pedestrian interval is used without accessible features, pedestrians with vision disabilities might begin crossing at the onset of the vehicular movement when vehicle operators are not expecting them to begin crossing.

Guidance:

22 *If a leading pedestrian interval is used, it should be at least 3 seconds in duration and should be timed to allow pedestrians to cross at least one lane of traffic or, in the case of a large corner radius, to travel far enough for pedestrians to establish their position ahead of the turning traffic before the turning traffic is released.*

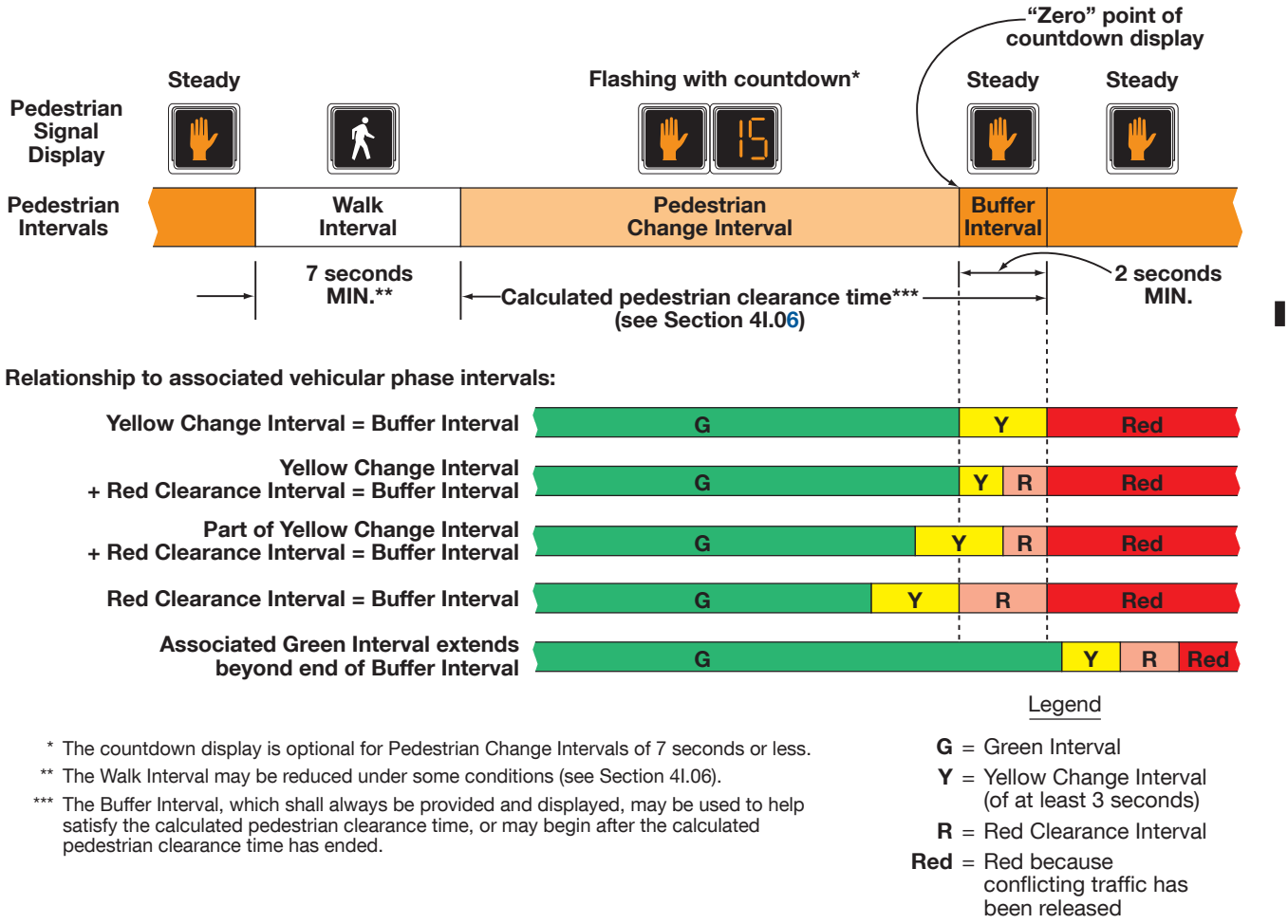
23 *If a leading pedestrian interval is used, consideration should be given to prohibiting turns across the crosswalk during the leading pedestrian interval.*

24 *At locations where a leading pedestrian interval is used, the minimum time for the WALKING PERSON (symbolizing WALK) indication should be the time provided for the leading pedestrian interval plus 7 seconds.*

Support:

25 At intersections with pedestrian volumes that are so high that drivers have difficulty finding an opportunity to turn across the crosswalk, the duration of the green interval for a parallel concurrent vehicular movement is sometimes intentionally set to extend beyond the pedestrian clearance time to provide turning drivers additional green time to make their turns while the pedestrian signal head is displaying a steady UPRAISED HAND (symbolizing DONT WALK) signal indication after pedestrians have had time to complete their crossings.

Figure 4I-4. Pedestrian Intervals



* The countdown display is optional for Pedestrian Change Intervals of 7 seconds or less.

** The Walk Interval may be reduced under some conditions (see Section 4I.06).

*** The Buffer Interval, which shall always be provided and displayed, may be used to help satisfy the calculated pedestrian clearance time, or may begin after the calculated pedestrian clearance time has ended.

Legend

G = Green Interval

Y = Yellow Change Interval (of at least 3 seconds)

R = Red Clearance Interval

Red = Red because conflicting traffic has been released

CHAPTER 4J. PEDESTRIAN HYBRID BEACONS

Section 4J.01 Application of Pedestrian Hybrid Beacons

Support:

01 A pedestrian hybrid beacon is a special type of hybrid beacon used to warn and control traffic at an unsignalized location to assist pedestrians in crossing a street or highway at a marked crosswalk.

Option:

02 A pedestrian hybrid beacon may be considered for installation to facilitate pedestrian crossings at a location that does not meet traffic signal warrants (see Chapter 4C), or at a location that meets traffic signal warrants under Sections 4C.05 and/or 4C.06 but a decision is made to not install a traffic control signal.

Standard:

03 **If used, pedestrian hybrid beacons shall be used in conjunction with signs and pavement markings (see Section 4J.02) to warn and control traffic at locations where pedestrians enter or cross a street or highway. A pedestrian hybrid beacon shall only be installed at a marked crosswalk.**

Guidance:

04 *If one of the signal warrants of Chapter 4C is met and a traffic control signal is justified by an engineering study, and if a decision is made to install a traffic control signal, it should be installed based upon the provisions of Chapters 4D through 4I and 4K.*

05 *If a traffic control signal is not justified under the signal warrants of Chapter 4C and if gaps in traffic are not adequate to permit pedestrians to cross, or if the speed for vehicles approaching on the major street is too high to permit pedestrians to cross, or if pedestrian delay is excessive, the need for a pedestrian hybrid beacon should be considered on the basis of an engineering study that considers major-street volumes, speeds, widths, and gaps in conjunction with pedestrian volumes, walking speeds, and delay.*

06 *For a major street where the posted or statutory speed limit or the 85th-percentile speed is 35 mph or less, the need for a pedestrian hybrid beacon should be considered if the engineering study finds that the plotted point representing the vehicles per hour on the major street (total of both approaches) and the corresponding total of all pedestrians crossing the major street for 1 hour (any four consecutive 15-minute periods) of an average day falls above the applicable curve in Figure 4J-1 for the length of the crosswalk.*

07 *For a major street where the posted or statutory speed limit or the 85th-percentile speed exceeds 35 mph, the need for a pedestrian hybrid beacon should be considered if the engineering study finds that the plotted point representing the vehicles per hour on the major street (total of both approaches) and the corresponding total of all pedestrians crossing the major street for 1 hour (any four consecutive 15-minute periods) of an average day falls above the applicable curve in Figure 4J-2 for the length of the crosswalk.*

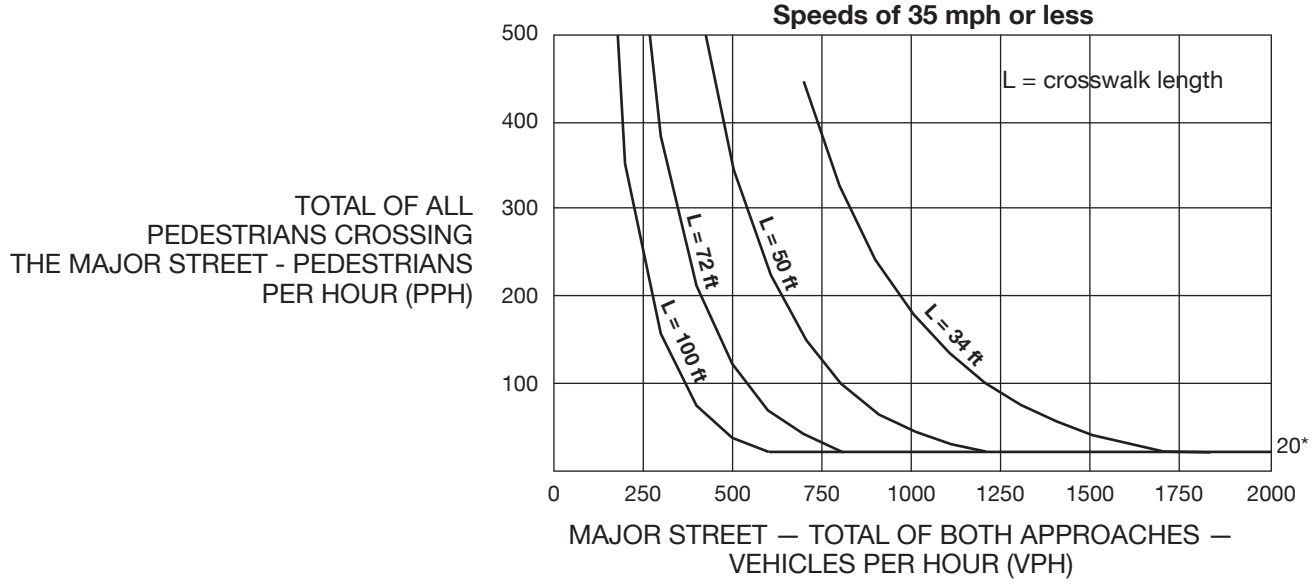
08 *For crosswalks that have lengths other than the four that are specifically shown in Figures 4J-1 and 4J-2, the values should be interpolated between the curves.*

Option:

09 The criteria for the pedestrian volume crossing the major street shown in Figures 4J-1 and 4J-2 may be reduced as much as 50 percent if the 15th-percentile crossing speed of pedestrians is less than 3.5 feet per second.

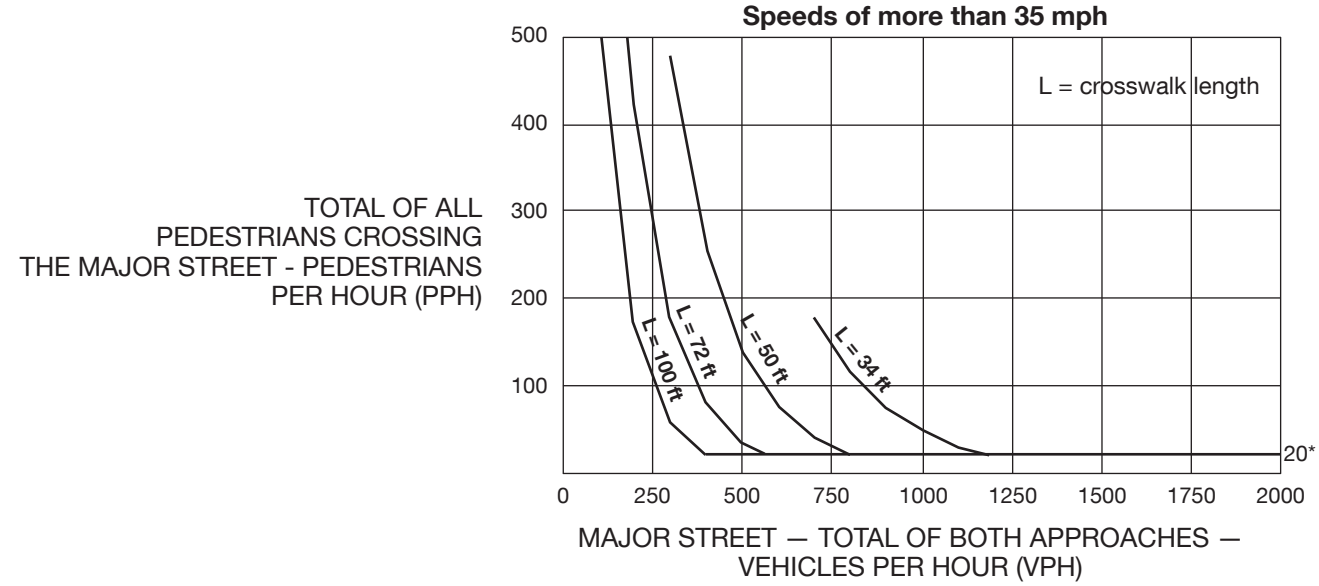
10 Where there is a divided street having a median of sufficient width for pedestrians to wait, the criteria for the major-street traffic volume shown in Figures 4J-1 and 4J-2 may be applied separately to each direction of vehicular traffic.

Figure 4J-1. Guidelines for the Installation of Pedestrian Hybrid Beacons on Low-Speed Roadways



* Note: 20 pph applies as the lower threshold volume

Figure 4J-2. Guidelines for the Installation of Pedestrian Hybrid Beacons on High-Speed Roadways



* Note: 20 pph applies as the lower threshold volume

Section 4J.02 Design of Pedestrian Hybrid Beacons

Standard:

01 **Except as otherwise provided in this Section, a pedestrian hybrid beacon shall meet the provisions of Chapters 4D through 4G, 4I, and 4J.**

02 **A pedestrian hybrid beacon face shall consist of three signal sections, with a CIRCULAR YELLOW signal indication centered below two horizontally-aligned CIRCULAR RED signal indications (see Figure 4J-3).**

03 **When an engineering study finds that installation of a pedestrian hybrid beacon is justified, then:**

- **A. At least two pedestrian hybrid beacon faces shall be installed for each approach of the major street;**
- **B. A stop line shall be installed for each approach to the crosswalk;**
- **C. A pedestrian signal head complying with the provisions set forth in Chapter 4I shall be installed at each end of the marked crosswalk;**
- **D. The pedestrian hybrid beacon shall be pedestrian actuated; and**
- **E. If the pedestrian hybrid beacon is installed at or immediately adjacent to an intersection with a minor street, a STOP sign shall be installed for each minor-street approach.**

Guidance:

04 *When an engineering study finds that installation of a pedestrian hybrid beacon is justified, then:*

- *A. Parking and other sight obstructions should be prohibited for at least 100 feet in advance of and at least 20 feet beyond the marked crosswalk, or site accommodations should be made through curb extensions or other techniques to provide adequate sight distance; and*
- *B. If installed within a signal system, the pedestrian hybrid beacon should be coordinated.*

05 *On approaches having posted or statutory speed limits or 85th-percentile speeds in excess of 35 mph and on approaches having traffic or operating conditions that would tend to obscure visibility of roadside hybrid beacon face locations, both of the minimum of two pedestrian hybrid beacon faces should be installed over the roadway.*

06 *On multi-lane approaches having posted or statutory speed limits or 85th-percentile speeds of 35 mph or less, either a pedestrian hybrid beacon face should be installed on each side of the approach (if a median of sufficient width exists) or at least one of the pedestrian hybrid beacon faces should be installed over the roadway.*

07 *A pedestrian hybrid beacon should comply with the signal face location provisions described in Sections 4D.05 through 4D.10.*

Option:

08 A CROSSWALK—STOP ON RED (symbolic circular red) (R10-23) or a STOP ON RED—YIELD ON FLASHING RED AFTER STOP (R10-23a) sign (see Section 2B.59) may be installed facing each major street approach.

09 A W11-2 (Pedestrian), S1-1 (School), or W11-15 (Trail) crossing warning sign with an AHEAD (W16-9P) supplemental plaque may be placed in advance of a pedestrian hybrid beacon. A Warning Beacon may be installed to supplement the W11-2, S1-1, or W11-15 sign.

10 Backplates (see Section 4D.06) may be used with pedestrian hybrid beacons.

Support:

11 Accessible pedestrian signals (see Chapter 4K) where a pedestrian hybrid beacon is used provide information in non-visual formats (such as audible tones and/or speech messages, and vibrating surfaces) so that a pedestrian with vision disabilities can know when to cross the street.

Guidance:

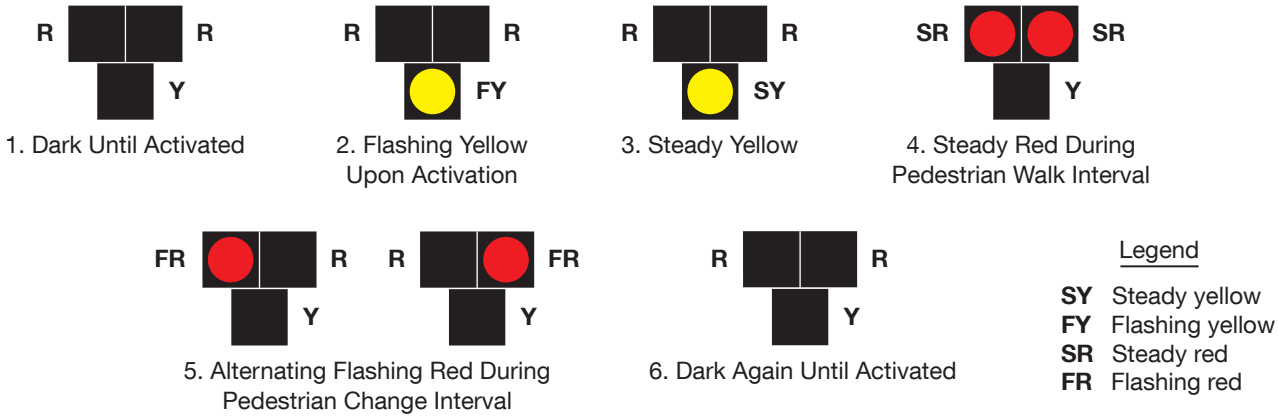
12 *If a Warning Beacon supplements a W11-2 sign in advance of a pedestrian hybrid beacon, it should be programmed to flash only when the pedestrian hybrid beacon is not in the dark mode.*

Standard:

13 **If a Warning Beacon is installed to supplement the W11-2 sign, the design and location of the Warning Beacon shall comply with the provisions of Sections 4S.01 and 4S.03.**

14 **Bicycle signal faces (see Chapter 4H) shall not be used at a pedestrian hybrid beacon.**

Figure 4J-3. Sequence for a Pedestrian Hybrid Beacon



Note: An optional steady red clearance interval may be added after Interval 3, and an optional short buffer interval (alternating flashing red while the pedestrian signal heads are displaying a steady UPRAISED HAND) may be added after Interval 5.

Section 4J.03 Operation of Pedestrian Hybrid Beacons

Standard:

01 **Pedestrian hybrid beacon indications shall be dark (not illuminated) during periods between actuations.**

02 **Following an actuation by a pedestrian, a pedestrian hybrid beacon face shall display a flashing CIRCULAR yellow signal indication, followed by a steady CIRCULAR yellow signal indication, followed by both steady CIRCULAR RED signal indications during the pedestrian walk interval, followed by alternating flashing CIRCULAR RED signal indications during the pedestrian change interval (see Figure 4J-3). Upon termination of the pedestrian change interval, the pedestrian hybrid beacon faces shall revert to a dark (not illuminated) condition.**

03 **Except as provided in Paragraph 4 of this Section, the pedestrian signal heads shall continue to display a steady UPRAISED HAND (symbolizing DONT WALK) signal indication when the pedestrian hybrid beacon faces are either dark or displaying flashing or steady CIRCULAR yellow signal indications. The pedestrian signal heads shall display a WALKING PERSON (symbolizing WALK) signal indication when the pedestrian hybrid beacon faces are displaying steady CIRCULAR RED signal indications. The pedestrian signal heads shall display a flashing UPRAISED HAND (symbolizing DONT WALK) signal indication when the pedestrian hybrid beacon faces are displaying alternating flashing CIRCULAR RED signal indications. Upon termination of the pedestrian change interval, the pedestrian signal heads shall revert to a steady UPRAISED HAND (symbolizing DONT WALK) signal indication.**

Option:

04 Where the pedestrian hybrid beacon is installed adjacent to a roundabout to facilitate crossings by pedestrians with vision disabilities and an engineering study determines that pedestrians without vision disabilities can be allowed to cross the roadway without actuating the pedestrian hybrid beacon, the pedestrian signal heads may be dark (not illuminated) when the pedestrian hybrid beacon faces are dark.

Guidance:

05 *The duration of the flashing yellow interval should be determined by engineering judgment.*

06 *The duration of the flashing yellow interval should not vary on a cycle-by-cycle basis.*

07 *If the pedestrian hybrid beacon is coordinated as a part of a signal system, it should remain in the dark condition after a pedestrian actuation has been received until the point in the background cycle when the predetermined duration of the flashing yellow interval needs to be initiated in order to achieve the appropriate coordinated offset.*

Option:

08 If a minimum dark time between activations of the pedestrian hybrid beacon has been set on the controller, the pedestrian hybrid beacon may remain in the dark condition after a pedestrian actuation has been received until the minimum dark time has been provided.

Support:

09 The minimum dark time is a preprogrammed time set in the controller that provides time between the pedestrian actuation and beginning of the flashing yellow interval. At locations in coordinated signal systems, the dark time can be variable based on when the pedestrian actuation occurs in the coordinated signal timing sequence.

Standard:

10 **The duration of the steady yellow change interval shall be determined using engineering practices in accordance with the provisions in Section 4F.17.**

Guidance:

11 *A steady yellow change interval should have a minimum duration of 3 seconds and a maximum duration of 6 seconds (see Section 4F.17). The longer intervals should be reserved for use on approaches with higher speeds.*

Option:

12 A steady red clearance interval may be used after the steady yellow change interval.

13 The alternating flashing CIRCULAR RED signal indications may continue to flash for a short period after the pedestrian change interval has terminated to provide a buffer interval for pedestrians.

Guidance:

14 *A pedestrian hybrid beacon that is located 200 feet or less from an active grade crossing should be preempted in accordance with the applicable provisions in Sections 4F.19 and 8D.09.*

Standard:

15 **If a pedestrian hybrid beacon is placed into a flashing mode by a conflict monitor (malfunction management unit) or by a manual switch, the pedestrian hybrid beacon faces shall display flashing CIRCULAR YELLOW signal indications to each approach of the major street and the pedestrian signal heads shall revert to a dark (not illuminated) condition.**

CHAPTER 4K. ACCESSIBLE PEDESTRIAN SIGNALS AND DETECTORS

Section 4K.01 General

Support:

01 Accessible pedestrian signals and detectors provide information in non-visual formats (such as audible tones and/or speech messages, and vibrating surfaces). The decision of when to use accessible pedestrian signals is subject to requirements of the Americans with Disabilities Act and Section 504 of the Rehabilitation Act of 1973.

02 The primary technique that pedestrians with vision disabilities use to cross streets at signalized locations is to initiate their crossing when they hear the traffic in front of them stop and the traffic alongside them begin to move, which often corresponds to the onset of the green interval. The existing environment is often not sufficient to provide the information that pedestrians with vision disabilities need to cross a roadway at a signalized location.

03 The following factors are relevant in determining whether a particular signalized location presents difficulties for pedestrians with vision disabilities to cross the roadway:

A. Potential demand for accessible pedestrian signals;
B. A request for accessible pedestrian signals;
C. Traffic volumes during times when pedestrians might be present, including periods of low traffic volumes or high turn-on-red volumes;
D. The complexity of the traffic signal phasing (such as split phases, protected turn phases, leading pedestrian intervals, and exclusive pedestrian phases); and
E. The complexity of the intersection geometry.

04 The factors that make crossing at a signalized location difficult for pedestrians with vision disabilities include: increasingly quiet vehicles, turns on red (which mask the beginning of the through phase), continuous turning movements, complex signal operations, circular intersections, and wide streets. In addition, low traffic volumes might make it difficult for pedestrians with vision disabilities to discern signal phase changes.

05 State and local organizations providing support services to pedestrians with vision and/or hearing disabilities can provide advice to the traffic engineer on site-specific accessibility decisions. In addition, orientation and mobility specialists or similar staff can provide advice to inform such decisions. The U.S. Access Board (www.access-board.gov) provides technical assistance for making pedestrian signal information accessible to persons with vision disabilities.

Standard:

06 **When used, accessible pedestrian signals shall be used in combination with pedestrian signal timing.**

07 **The information provided by an accessible pedestrian signal shall indicate which pedestrian crossing is served by each device.**

08 **Under steady (stop-and-go) operation, accessible pedestrian signals shall not be limited in operation by the time of day or day of week.**

Option:

09 Accessible pedestrian signal detectors may be push buttons or passive detection devices.

10 At locations with pretimed traffic control signals or non-actuated approaches, pedestrian push buttons may be used to activate the accessible pedestrian signals.

Support:

11 Accessible pedestrian signals are typically integrated into the pedestrian detector (push button), so the audible tones and/or messages come from the push button housing. They have a push button locator tone and a vibrotactile arrow, and can include audible beaconing and other special features.

Option:

12 The name of the street to be crossed may also be provided in accessible format, such as Braille or raised characters. Tactile maps of crosswalks may also be provided.

Support:

13 Specifications regarding Braille or raised characters can be found in the U.S. Department of Justice 2010 ADA Standards for Accessible Design, September 15, 2010, 28 CFR 35 and 36, Americans with Disabilities Act of 1990.

Standard:

14 **At accessible pedestrian signal locations where pressing the pedestrian push button is necessary to activate the walk interval, pressing the pedestrian push button shall activate both the walk interval and the accessible pedestrian signals.**

Section 4K.02 Location

Support:

01 Accessible pedestrian signals that are located as close as possible to pedestrians waiting to cross the street provide the clearest and least ambiguous indication of which pedestrian crossing is served by a device.

Guidance:

02 *Push buttons for accessible pedestrian signals should be located in accordance with the provisions of Section 4I.05 and should be located as close as possible to the crosswalk line furthest from the center of the intersection and as close as possible to the curb ramp.*

Standard:

03 **Except for the situation regarding simultaneous walk indications for all crosswalks, if two accessible pedestrian push buttons are placed less than 10 feet apart or on the same pole (see Paragraphs 7 and 8 in Section 4I.05), each accessible pedestrian push button shall be provided with the following features:**

- **A. A push button locator tone,**
- **B. A vibrotactile walk indication,**
- **C. A speech walk message for the WALKING PERSON (symbolizing WALK) indication (see Section 4K.03), and**
- **D. A speech push button information message (see Section 4K.05).**

04 **If the pedestrian clearance time is sufficient only to cross from the curb or edge of pavement to a median of sufficient width for pedestrians to wait and accessible pedestrian signal detectors are used, an additional accessible pedestrian signal detector shall be provided in the median.**

Section 4K.03 Walk Indications

Support:

01 Technology that provides different sounds for each non-concurrent signal phase has frequently been found to provide ambiguous information. Research indicates that a rapid percussive tone for each crossing coming from accessible pedestrian signal devices on separated poles located close to each crosswalk provides unambiguous information to pedestrians with vision disabilities. Vibrotactile indications provide information to pedestrians who are blind and deaf and are also used by pedestrians who are blind or who have low vision to confirm the walk signal in noisy situations.

Standard:

02 **Accessible pedestrian signals shall have both audible and vibrotactile walk indications.**

03 **Vibrotactile walk indications shall be provided by a vibrotactile arrow that is located on the push button (see Paragraph 1 in Section 4K.04). The vibrotactile arrow shall vibrate during the walk interval.**

04 **Accessible pedestrian signals shall have an audible walk indication during the walk interval only.**

05 **The audible walk indication shall be audible at the beginning of the associated crosswalk. The accessible walk indication shall have the same duration as the pedestrian walk signal except when the pedestrian signal rests in walk.**

Guidance:

06 *If the pedestrian signal rests in walk, the accessible walk indication should be limited to the first 7 seconds of the walk interval. The accessible walk indication should be recalled by a button press during the walk interval provided that the crossing time remaining is longer than the pedestrian change interval.*

Standard:

07 **Where two accessible pedestrian signals on one corner, or in a median, that are associated with different phases are placed less than 10 feet apart, the audible walk indication shall be a speech walk message (see Paragraph 3 in Section 4K.02). In all other cases, including at midblock crossings, on corners where only one accessible pedestrian signal is present, in a median, and on corners where two accessible pedestrian signals are separated by a distance of at least 10 feet, the audible walk indication shall be a percussive tone.**

08 **Audible tone walk indications shall repeat at eight to ten ticks per second. Audible tones used as walk indications shall consist of multiple frequencies with a dominant component at 880 Hz.**

Guidance:

09 *The volume of audible walk indications and push button locator tones (see Section 4K.04) should be set to be a maximum of 5 dBA louder than ambient sound, except when audible beaconing is provided in response to an extended push button press.*

Standard:

10 **Automatic volume adjustment up to a maximum volume of 100 dBA in response to ambient traffic sound level shall be provided.**

Guidance:

11 *The sound level of audible walk indications and push button locator tones should be adjusted to be low enough to avoid misleading pedestrians with vision disabilities when the following conditions exist:*

A. Where there is an island that allows unsignalized right turns across a crosswalk between the island and the sidewalk.

B. Where multi-leg approaches or complex signal phasing require more than two pedestrian phases, such that it might be unclear which crosswalk is served by each audible tone.

C. At intersections where a diagonal pedestrian crossing is allowed, or where one street receives a WALKING PERSON (symbolizing WALK) signal indication simultaneously with another street.

Option:

12 An alert tone, which is a very brief burst of high-frequency sound at the beginning of the audible walk indication that rapidly decays to the frequency of the walk tone, may be used to alert pedestrians to the beginning of the walk interval.

Support:

13 An alert tone can be particularly useful if the walk tone is not easily audible in some traffic conditions.

14 Speech walk messages communicate to pedestrians which street has the walk interval. To be a useful system, the words and their meaning need to be correctly understood by all users in the context of the street environment where they are used. Because of this, tones are the preferred means of providing audible walk indications except where two accessible pedestrian signals on one corner are not separated by a distance of at least 10 feet.

15 If speech walk messages are used, pedestrians have to know the names of the streets that they are crossing in order for the speech walk messages to be unambiguous. In getting directions to travel to a new location, pedestrians with vision disabilities do not always get the name of each street to be crossed. Therefore, it is desirable to give users of accessible pedestrian signals the name of the street controlled by the push button. This can be done by means of a speech push button information message (see Section 4K.05) during the flashing or steady UPRAISED HAND intervals, or by raised print and Braille labels on the push button housing.

16 By combining the information from the push button message or Braille label, the vibrotactile arrow aligned in the direction of travel on the relevant crosswalk, and the speech walk message, pedestrians with vision disabilities are able to correctly respond to speech walk messages even if there are two push buttons on the same pole.

Standard:

17 **If speech walk messages are used to communicate the walk interval, they shall provide a clear message that the walk interval is in effect, as well as to which crossing it applies.**

Guidance:

18 *Speech walk messages that are used at intersections having pedestrian phasing that is concurrent with vehicular phasing should be patterned after the model: "Broadway. Walk sign is on to cross Broadway."*

19 *Speech walk messages that are used at intersections having exclusive pedestrian phasing should be patterned after the model: "Walk sign is on for all crossings."*

20 *Speech walk messages should not contain any additional information, except they should include designations such as "Street" or "Avenue" where this information is necessary to avoid ambiguity at a particular location.*

21 *Speech walk messages should not state or imply a command to the pedestrian, such as "Cross Broadway now." Speech walk messages should not tell pedestrians that it is "safe to cross," because it is always the pedestrian's responsibility to check actual traffic conditions.*

Standard:

22 **A speech walk message is not required at times when the walk interval is not timing, but, if provided:**

A. It shall begin with the term "wait."

B. It need not be repeated for the entire time that the walk interval is not timing.

23 **If a pilot light (see Section 4I.05) is used at an accessible pedestrian signal location, each actuation shall be accompanied by the speech message "wait."**

Option:

24 Accessible pedestrian signals that provide speech walk messages may provide similar messages in languages other than English, if needed.

Standard:

25 **If used, speech walk messages in a language other than English shall be stated first in English, and then repeated in the second language, alternating back and forth while the walk interval is timing.**

Section 4K.04 Vibrotactile Arrows and Locator Tones

Standard:

01 **To enable pedestrians with vision disabilities to distinguish and locate the appropriate push button at an accessible pedestrian signal location, and to help them align with the crosswalk, each push button shall clearly indicate by means of a vibrotactile arrow which crosswalk signal is actuated by the push button. Vibrotactile arrows shall be located on the button of the push button assembly, shall have high visual contrast (light on dark or dark on light), and shall be aligned parallel to the direction of travel on the associated crosswalk.**

02 **A locator tone shall be incorporated into the accessible pedestrian signal equipment to help pedestrians with vision disabilities locate the vibrotactile arrow, and the associated push button if a push button is provided.**

Support:

03 A push button locator tone is a repeating sound that informs approaching pedestrians that a push button to actuate pedestrian timing or receive additional information exists, and that enables pedestrians with vision disabilities to locate the push button.

Standard:

04 **Push button locator tones shall have a duration of 0.15 seconds or less, and except as provided in Paragraph 5 of this Section, push button locator tones shall repeat at 1-second intervals at all times that the audible walk indication is not active, including during the pedestrian change interval and during the time that the pedestrian signal is resting in walk (see Paragraph 6 in Section 4K.03).**

Option:

05 The push button locator tone may default to a deactivated mode during periods when the steady UPRAISED HAND (symbolizing DON'T WALK) signal indication is being displayed for the associated crosswalk if a passive pedestrian detection system is implemented that activates the locator tone at all times (other than when the audible walk indication is active) that a pedestrian is present within a 12-foot radius from the push button location. Where pedestrian facilities (such as sidewalks) are present, the passive detection requirement may be reduced such that it only applies to pedestrians who are on the pedestrian facilities within the 12-foot radius from the push button location.

Standard:

06 **Push button locator tones shall be deactivated when the traffic control signal or pedestrian hybrid beacon is operating in a flashing mode. This requirement shall not apply to traffic control signals or pedestrian hybrid beacons that are activated from a flashing or dark mode to a steady (stop-and-go) mode by pedestrian actuations.**

07 **Push button locator tones shall be intensity responsive to ambient sound.**

Guidance:

08 *Push button locator tones should be audible 6 to 12 feet from the push button, or to the building line, whichever is less.*

Support:

09 Section 4K.03 contains additional provisions regarding the volume and sound level of push button locator tones.

Section 4K.05 Extended Push Button Press Features

Option:

01 Pedestrians may be provided with additional features such as increased crossing time, audible beaconing, or a speech push button information message as a result of an extended push button press.

Standard:

02 **If an extended push button press (see Paragraph 18 in Section 4I.05) is used to provide any additional feature(s), a push button press of less than one second shall actuate only the pedestrian timing and any associated accessible walk indication, and a push button press of one second or more shall actuate the pedestrian timing, any associated accessible walk indication, and any additional feature(s).**

03 **If additional crossing time is provided by means of an extended push button press, a PUSH BUTTON FOR 2 SECONDS FOR EXTRA CROSSING TIME (R10-32P) plaque (see Section 4I.05) shall be installed adjacent to the pedestrian push button detector.**

Support:

04 Audible beaconing is the use of an audible signal in such a way that pedestrians with vision disabilities can home in on the signal that is located on the far end of the crosswalk as they cross the street.

05 Not all crosswalks at an intersection need audible beaconing. Audible beaconing is not appropriate at locations with channelized turns or split phasing, because of the possibility of confusion.

Guidance:

06 *Audible beaconing should be considered following an engineering study at:*

- *A. Crosswalks longer than 70 feet, unless those crosswalks are divided by a median that has another accessible pedestrian signal with a locator tone;*
- *B. Crosswalks that are skewed;*
- *C. Intersections with irregular geometry, such as more than four legs;*
- *D. Crosswalks where audible beaconing is requested by a person with vision disabilities; or*
- *E. Other locations where a study indicates audible beaconing would be beneficial.*

07 *If audible beaconing is used, it should be initiated by an extended push button press.*

Standard:

08 **If audible beaconing is used, the volume of the push button locator tone during the pedestrian change interval of the called pedestrian phase shall be increased up to a maximum of 100 dBA, and shall come from a loudspeaker that is mounted at the far end of the crosswalk at a height of 7 to 10 feet above the pavement.**

Guidance:

09 *The audible beaconing loudspeaker mounted at the far end of the crosswalk should be within the width of the crosswalk.*

Support:

10 When the locator tone is active during the pedestrian change interval at a traffic control signal or pedestrian hybrid beacon where audible beaconing is used, the locator tone from the audible beaconing loudspeaker is at an elevated volume, while the locator tone from the accessible pedestrian signal is at its normal, quiet setting.

Option:

11 The sound level of the accessible pedestrian signal walk indication and subsequent push button locator tone may be increased by an extended push button press.

12 Speech push button information messages may provide intersection identification, as well as information about unusual intersection signalization and geometry, such as notification regarding exclusive pedestrian phasing, leading pedestrian intervals, split phasing, diagonal crosswalks, and medians or islands.

Standard:

13 **If speech push button information messages are made available by actuating the accessible pedestrian signal detector, they shall only be actuated when the walk interval is not timing. They shall begin with the term "Wait," followed by intersection identification information modeled after: "Wait to cross Broadway at Grand." If information on intersection signalization or geometry is also given, it shall follow the intersection identification information.**

Guidance:

14 *Speech push button information messages should not be used to provide landmark information or to inform pedestrians with vision disabilities about detours or temporary traffic control situations.*

Support:

15 Additional information on the structure and wording of speech push button information messages is included in the Institute of Transportation Engineers' "Electronic Toolbox for Making Intersections More Accessible for Pedestrians Who Are Blind or Visually Impaired."

CHAPTER 4L. RECTANGULAR RAPID FLASHING BEACONS

Section 4L.01 Application of Rectangular Rapid Flashing Beacons

Option:

01 A pedestrian-activated and/or bicyclist-activated rectangular rapid flashing beacon (RRFB) may be used to provide supplemental emphasis to pedestrian, school, and trail warning signs at marked crosswalks across uncontrolled approaches.

Standard:

02 **An RRFB shall only be installed to function as a Warning Beacon (see Section 4S.03). Except as otherwise provided in this Chapter, all other provisions of the MUTCD applicable to Warning Beacons shall apply to RRFBs.**

03 **An RRFB shall only be used to supplement a post-mounted W11-2 (Pedestrian), S1-1 (School), or W11-15 (Trail) crossing warning sign with a diagonal downward arrow (W16-7P) plaque, or an overhead-mounted W11-2 , S1-1, or W11-15 crossing warning sign, located at a marked crosswalk.** Rev. 1

04 **Except for crosswalks across the approach to or egress from a roundabout, or crosswalks across free-flow turn lanes separated by a channelizing island, an RRFB shall not be used for crosswalks across approaches controlled by YIELD signs, STOP signs, traffic control signals, or pedestrian hybrid beacons.**

Option:

05 An additional RRFB may be installed on that approach in advance of the crosswalk, as a Warning Beacon to supplement a W11-2 (Pedestrian), S1-1 (School), or W11-15 (Trail) crossing warning sign with an AHEAD (W16-9P) or distance (W16-2P or W16-2aP) plaque.

Standard:

06 **If an additional RRFB is installed on the approach in advance of the crosswalk, it shall be supplemental to and not a replacement for the RRFB at the crosswalk itself.**

Section 4L.02 Design of Rectangular Rapid Flashing Beacons

Standard:

01 **Each RRFB unit shall consist of two rapidly-flashed rectangular-shaped yellow indications, each with an LED-array based pulsing light source. The size of each RRFB indication shall be at least 5 inches wide by at least 2 inches high.**

02 **The two RRFB indications for each RRFB unit shall be aligned horizontally, with the longer dimension horizontal and with a minimum space between the two indications of at least 7 inches, measured from nearest edge of one indication to the nearest edge of the other indication. The outside edges of the RRFB indications, including any housings, shall not project beyond the outside edges of the W11-2, S1-1, or W11-15 sign that it supplements.**

03 **An RRFB unit shall not be installed independent of the crossing warning signs for the approach that the RRFB faces. If the RRFB unit is supplementing a post-mounted sign, the RRFB unit shall be installed on the same support as the associated W11-2, S1-1, or W11-15 crossing warning sign and plaque. If the RRFB unit is supplementing an overhead-mounted sign, the RRFB unit shall be mounted directly above the top of sign or below the bottom of the sign.**

Option:

04 As a specific exception to Paragraph 6 of Section 4S.01, the RRFB unit associated with a post-mounted sign and plaque may be located between and immediately adjacent to the bottom of the crossing warning sign and the top of the supplemental downward diagonal arrow plaque (or, in the case of a supplemental advance sign, the AHEAD or distance plaque) or within 12 inches above the crossing warning sign, rather than the recommended minimum of 12 inches above or below the sign assembly.

05 Signal visors and backplates, with or without a yellow retroreflective strip, may be used with RRFB units based on provisions in Section 4D.06.

Standard:

06 **For any approach on which RRFBs are used to supplement post-mounted signs, at least two W11-2, S1-1, or W11-15 crossing warning signs (each with an RRFB unit and a W16-7P plaque) shall be installed at the crosswalk, one on the right-hand side of the roadway and one on the left-hand side of the roadway.**

Guidance:

07 *On a divided highway, the left-hand side RRFB assembly should be installed on the median, if practicable, rather than on the far left side of the highway.*

Standard:

08 **For any approach on which RRFBs are used to supplement an overhead-mounted sign, at least one W11-2 , S1-1, or W11-15 crossing warning sign (without a W16-7P plaque) located approximately over the center of the lanes of the approach (or where optimum visibility can be achieved) shall be installed at the crosswalk.**

09 **If used at intersections, the design of the RRFBs shall conform to the requirements for post-mounted or overhead placement described in Paragraph 3 of this Section.**

Option:

10 RRFBs may be installed at intersections with more than one crosswalk on the same uncontrolled approach (see Figure 4L-1).

11 If used at intersections with two crosswalks on an uncontrolled approach, post-mounted RRFBs may be installed to face only one direction of travel at the first crosswalk that traffic encounters (see Figure 4L-1).

Standard:

12 **The light intensity of the yellow indications during daytime conditions shall meet the minimum specifications for Class 1 yellow peak luminous intensity in the publication "Directional Flashing Optical Warning Devices for Authorized Emergency, Maintenance, and Service Vehicles J595," 2005, Society of Automotive Engineers (SAE).**

Option:

13 If the RRFB indications are so bright that they cause excessive glare during nighttime conditions, an automatic signal dimming device may be used to reduce the brilliance of the RRFB indications during nighttime conditions.

Standard:

14 **If pedestrian push button detectors (rather than passive detection) are used to actuate the RRFB indications, a PUSH BUTTON FOR WARNING LIGHTS/WAIT FOR GAP IN TRAFFIC (R10-25) sign (see Section 2B.58) shall be installed explaining the purpose and use of the pedestrian push button detector.**

Support:

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15 Section 4I.05 contains further information about pedestrian push button detector location criteria and Chapter 4K contains further information on push button locator tones.

16 Section 4H.12 contains information about bicyclist push buttons.

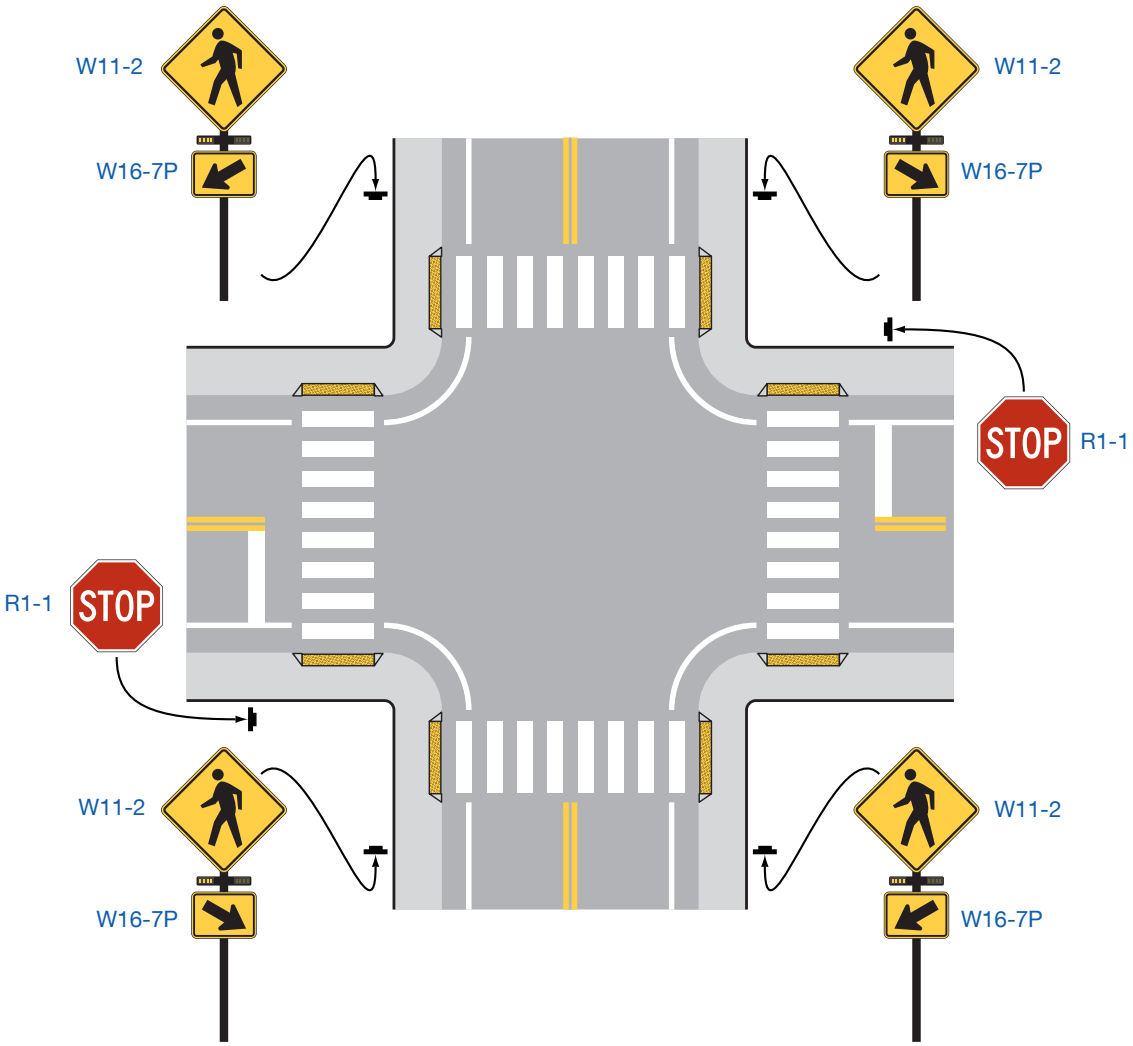
Guidance:

17 *An audible information device should be used with RRFBs to assist pedestrians with vision disabilities.*

Option:

18 A small light directed at and visible to pedestrians in the crosswalk may be installed integral to the RRFB or pedestrian push button detector to give confirmation that the RRFB is in operation.

Figure 4L-1. Example of RRFBs at Uncontrolled, Marked Crosswalks at an Intersection



Notes:

1. When activated, the RRFBs on both approaches shall simultaneously commence operation of their rapid flashing indications and shall cease operation simultaneously.
2. If placed overhead, follow the requirements of Paragraph 8 of Section 4L.02, except that the signs may be placed approximately over the center of the intersection.

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Section 4L.03 Operation of Rectangular Rapid Flashing Beacons

Standard:

01 **The RRFB shall be normally dark, shall initiate operation only upon pedestrian actuation, and shall cease operation at a predetermined time after the pedestrian actuation or, with passive detection, after the pedestrian clears the crosswalk.**

02 **All RRFB units associated with a given crosswalk (including those with an advance crossing sign, if used) shall, when activated, simultaneously commence operation of their rapid flashing indications and shall cease operation simultaneously.**

Guidance:

03 *The minimum duration of a predetermined period of operation of the RRFBs following each actuation should be based on the procedures for the timing of pedestrian clearance times for pedestrian signals (see Section 4I.06).*

Support:

04 One consideration for lengthening the duration of the predetermined period of operation of the RRFBs is adding the perception/reaction time for pedestrians to confirm that a vehicle will yield or stop.

Standard:

05 **The predetermined flash period shall be immediately initiated each and every time that a pedestrian is detected either through passive detection or as a result of a pedestrian pressing a push button detector, including when pedestrians are detected while the RRFBs are already flashing and when pedestrians are detected immediately after the RRFBs have ceased flashing.**

06 **When activated, the two yellow indications in each RRFB unit shall flash in a rapidly flashing sequence. As a specific exception to the requirements for the flash rate of beacons provided in Paragraph 3 of Section 4S.01, RRFBs shall use a much faster flash rate and shall provide 75 flashing sequences per minute.**

07 **Except as provided in Paragraph 8 of this Section, during each 800-millisecond flashing sequence, the left and right RRFB indications shall operate using the following sequence:**

- **A. The RRFB indication on the left-hand side shall be illuminated for approximately 50 milliseconds.**
- **B. Both RRFB indications shall be dark for approximately 50 milliseconds.**
- **C. The RRFB indication on the right-hand side shall be illuminated for approximately 50 milliseconds.**
- **D. Both RRFB indications shall be dark for approximately 50 milliseconds.**
- **E. The RRFB indication on the left-hand side shall be illuminated for approximately 50 milliseconds.**
- **F. Both RRFB indications shall be dark for approximately 50 milliseconds.**
- **G. The RRFB indication on the right-hand side shall be illuminated for approximately 50 milliseconds.**
- **H. Both RRFB indications shall be dark for approximately 50 milliseconds.**
- **I. Both RRFB indications shall be illuminated for approximately 50 milliseconds.**
- **J. Both RRFB indications shall be dark for approximately 50 milliseconds.**
- **K. Both RRFB indications shall be illuminated for approximately 50 milliseconds.**
- **L. Both RRFB indications shall be dark for approximately 250 milliseconds.**

08 **The flash rate of each individual RRFB indication, as applied over the full flashing sequence, shall not be more than 5 flashes per second, to avoid frequencies that might cause seizures.**

09 **If an audible information device is used in conjunction with an RRFB, the audible information device shall not use vibrotactile indications or percussive indications.**

Guidance:

10 *If an audible information device is used in conjunction with an RRFB, the audible message should be a speech message that says, "Warning lights are flashing." The audible message should be spoken twice.*

CHAPTER 4M. TRAFFIC CONTROL SIGNALS FOR EMERGENCY-VEHICLE ACCESS

Section 4M.01 Application of Emergency-Vehicle Traffic Control Signals

Support:

01 An emergency-vehicle traffic control signal is a special traffic control signal that directs all conflicting traffic to stop in order to permit the driver of an authorized emergency vehicle to proceed into the roadway or intersection.

Option:

02 An emergency-vehicle traffic control signal may be installed at a location that does not meet other traffic signal warrants such as at an intersection or other location to permit direct access from a building housing the emergency vehicle.

Guidance:

03 *If a traffic control signal is not justified under the signal warrants of Chapter 4C and if gaps in traffic are not adequate to permit the timely entrance of emergency vehicles, or the stopping sight distance for vehicles approaching on the major street is insufficient for emergency vehicles, installing an emergency-vehicle traffic control signal should be considered. If one of the signal warrants of Chapter 4C is met and a traffic control signal is justified by an engineering study, and if a decision is made to install a traffic control signal, it should be installed based upon the provisions of Chapters 4D through 4I and 4K.*

04 *The sight distance determination should be based on the location of the visibility obstruction for the critical approach lane for each street or drive and the posted or statutory speed limit or 85th-percentile speed on the major street, whichever is higher.*

Option:

05 If a traffic control signal is not justified under the signal warrants of Chapter 4C, an emergency vehicle signal may be considered if an engineering study finds that both of the following two criteria are met:

A. 75% or more of the major street approach for the interruption of Continuous Traffic Warrant (Condition B of Warrant 1, see Section 4C.02).
B. A minimum of 30 calls per month (360 per year) requiring an emergency vehicle response and any of the following:
    1. Poor sight distance which cannot be corrected economically, or
    2. A crash problem, or
    3. High approach speeds.

Section 4M.02 Design of Emergency-Vehicle Traffic Control Signals

Standard:

01 **Except as otherwise provided in this Section, an emergency-vehicle traffic control signal shall meet the requirements of this Manual.**

02 **An Emergency Vehicle (W11-8) sign (see Section 2C.54) with an EMERGENCY SIGNAL AHEAD (W11-12P) supplemental plaque shall be placed in advance of all emergency-vehicle traffic control signals. If a Warning Beacon is installed to supplement the W11-8 sign, the design and location of the beacon shall comply with the Standards of Sections 4S.01 and 4S.03.**

Guidance:

03 *At least one of the two required signal faces for each approach on the major street should be located over the roadway.*

04 *The following size signal indications should be used for emergency-vehicle traffic control signals: 12-inch diameter for steady red and steady yellow circular signal indications and any arrow indications, and 8-inch diameter for green or flashing yellow circular signal indications.*

Standard:

05 **An EMERGENCY SIGNAL (R10-13) sign (see Section 2B.59) shall be installed facing each major-street approach.**

06 **If an overhead signal face is provided, the EMERGENCY SIGNAL sign shall be mounted adjacent to the overhead signal face.**

Option:

07 An approach that only serves emergency vehicles may be provided with only one signal face consisting of one or more signal sections.

08 Besides using an 8-inch diameter signal indication, other appropriate means to reduce the flashing yellow light output may be used.

Section 4M.03 Operation of Emergency-Vehicle Traffic Control Signals

Standard:

01 **Green signal indications for emergency vehicles at signalized locations operating in the steady (stop-and-go) mode shall be obtained as provided in Section 4F.19.**

02 **As a minimum, the signal indications, sequence, and manner of operation of an emergency-vehicle traffic control signal installed at a midblock location shall be as follows:**

- **A. The signal indication, between emergency-vehicle actuations, shall be either green or flashing yellow. If the flashing yellow signal indication is used instead of the green signal indication, it shall be displayed in the normal position of the green signal indication, while the steady red and steady yellow signal indications shall be displayed in their normal positions.**
- **B. When an emergency-vehicle actuation occurs, a steady yellow change interval followed by a steady red interval shall be displayed to traffic on the major street.**
- **C. A yellow change interval is not required following the green interval for the emergency-vehicle driveway.**

Guidance:

03 *Emergency-vehicle traffic control signals located at intersections should either be operated in the flashing mode (see Sections 4G.01 and 4G.03) between emergency-vehicle actuations or be full-actuated or semi-actuated to accommodate normal vehicular and pedestrian traffic on the streets.*

04 *Warning Beacons, if used with an emergency-vehicle traffic control signal, should be flashed only:*

- *A. For an appropriate time in advance of and during the steady yellow change interval for the major street, and*
- *B. During the steady red interval for the major street.*

05 *The duration of the steady red interval for traffic on the major street should be determined by on-site test-run time studies, but should not exceed 1.5 times the time required for the emergency vehicle to clear the path of conflicting vehicles.*

Option:

06 An emergency-vehicle traffic control signal sequence may be initiated manually from a local control point such as a fire station or law enforcement headquarters or from an emergency vehicle equipped for remote operation of the signal.

CHAPTER 4N. WARNING BEACONS FOR EMERGENCY VEHICLES

Section 4N.01 Application of Emergency Vehicle Warning Beacons

Option:

01 An emergency vehicle warning beacon may be installed if there is a minimum of 30 calls per month (360 per year) requiring an emergency vehicle response and at least one of the following:

A. Poor sight distance which cannot be corrected economically, or
B. A crash problem, or
C. High approach speed.

Guidance:

02 *The sight distance determination should be based on the location of the visibility obstruction for the critical approach lane for each street or drive and the posted or statutory speed limit or 85th-percentile speed on the major street, whichever is higher.*

Standard:

03 **If used, an emergency vehicle warning beacon shall be installed on top of the WATCH FOR EMERGENCY VEHICLES (W11-12T) sign and the WHEN FLASHING (W16-13P) plaque shall be installed below the W11-12T sign (see Section 2C.54). Flashing beacon units and their mountings shall follow the provisions of Chapter 4D and 4S.**

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Figure 4N-1. ~~Sequence for an Emergency-Vehicle Hybrid Beacon~~ DELETED

Section 4N.02 ~~Design of Emergency-Vehicle Hybrid Beacons~~ DELETED

Section 4N.03 ~~Operation of Emergency-Vehicle Hybrid Beacons~~ DELETED

CHAPTER 4O. TRAFFIC CONTROL SIGNALS FOR ONE-LANE, TWO-WAY FACILITIES

Section 4O.01 Application of Traffic Control Signals for One-Lane, Two-Way Facilities

Support:

01 A traffic control signal at a narrow bridge, tunnel, or roadway section that is not of sufficient width for two opposing vehicles to pass is a special signal that alternates which direction of travel is permitted to proceed.

02 Temporary traffic control signals (see Sections 4D.11 and 6L.01) are the most frequent application of traffic control signals for one-lane, two-way facilities.

Guidance:

03 *Sight distance across or through the one-lane, two-way facility should be considered as well as the approach speed and sight distance approaching the facility when determining whether traffic control signals should be installed.*

Option:

04 At a narrow bridge, tunnel, or roadway section where a traffic control signal is not justified under the conditions of Chapter 4C, a traffic control signal may be used if gaps in opposing traffic do not permit the flow of traffic through the one-lane section of roadway.

Section 4O.02 Design of Traffic Control Signals for One-Lane, Two-Way Facilities

Standard:

01 **The provisions of Chapters 4D through 4G shall apply to traffic control signals for one-lane, two-way facilities, except that:**

- **A. The durations of the red clearance intervals shall be adequate to clear the one-lane section of conflicting vehicles; and**
- **B. Adequate means, such as interconnection, shall be provided to prevent conflicting signal indications, such as green and green, at opposite ends of the section.**

Section 4O.03 Operation of Traffic Control Signals for One-Lane, Two-Way Facilities

Guidance:

01 *Traffic control signals at one-lane, two-way facilities should operate in a manner consistent with traffic requirements.*

02 *Adequate time should be provided to allow traffic to clear the narrow facility before opposing traffic is allowed to move. Engineering judgment should be used to determine the proper timing for the signal.*

Standard:

03 **When in the flashing mode, the signal indications shall flash red.**

CHAPTER 4P. TRAFFIC CONTROL SIGNALS FOR FREEWAY ENTRANCE RAMPS

Section 4P.01 Application of Freeway Entrance Ramp Control Signals

Support:

01 Ramp control signals are traffic control signals that control the flow of traffic entering the freeway facility This is often referred to as "ramp metering."

02 Freeway entrance ramp control signals are sometimes used if controlling traffic entering the freeway could reduce the total expected delay to traffic in the freeway corridor, including freeway ramps and local streets.

Guidance:

03 *The installation of ramp control signals should be preceded by an engineering study of the physical and traffic conditions on the highway facilities likely to be affected. The study should include the ramps and ramp connections and the surface streets that would be affected by the ramp control, as well as the freeway section concerned.*

Support:

04 Information on conditions that might justify freeway entrance ramp control signals, factors to be evaluated in traffic engineering studies for ramp control signals, design of ramp control signals, and operation of ramp control signals can be found in the FHWA's "Ramp Management and Control Handbook."

Section 4P.02 Design of Freeway Entrance Ramp Control Signals

Standard:

01 **Ramp control signals shall meet all of the standard design specifications for traffic control signals, except as otherwise provided in this Section.**

02 **The signal face for freeway entrance ramp control signals shall be either a two-section signal face containing red and green signal indications or a three-section signal face containing red, yellow, and green signal indications.**

Option:

03 Ramp control signals may be placed in the dark mode (no indications displayed) when not in use.

04 Ramp control signals may be used to control some, but not all, lanes on a ramp, such as when non-metered HOV bypass lanes are provided on a ramp.

Standard:

05 **If only one controlled lane is present on an entrance ramp, or if more than one controlled lane is present on an entrance ramp and the ramp control signals are operated such that green signal indications are always displayed simultaneously to all of the controlled lanes on the ramp, then a minimum of two signal faces per ramp shall face entering traffic.**

06 **If two controlled lanes are present on an entrance ramp and the ramp control signals are operated such that green signal indications are not always displayed simultaneously to both of the controlled lanes on the ramp, then one signal face shall be provided over the approximate center of each separately-controlled lane.**

07 **If three or more controlled lanes are present on an entrance ramp and the ramp control signals are operated such that green signal indications are not always displayed simultaneously to all of the controlled lanes on the ramp, then one signal face shall be provided over the approximate center of each separately-controlled lane.**

Guidance:

08 *Additional side-mounted signal faces should be considered for ramps with three or more separately-controlled lanes.*

Option:

09 For entrance ramps with only one controlled lane, the two required signal faces may both be mounted at the side of the roadway on a single pole (as a specific exception to the normal 8-foot minimum lateral separation of signal faces required by Section 4D.07), with the lower signal face installed at a minimum mounting height of 4.5 feet.

10 For entrance ramps with two or more controlled lanes, if two signal faces are installed for the right-hand lane or for the left-hand lane, the two signal faces for that lane may both be mounted at the closest side of the roadway on a single pole (as a specific exception to the normal 8-foot minimum lateral separation of signal faces required by Section 4D.07), with the lower signal face installed at a minimum mounting height of 4.5 feet.

Guidance:

11 *Ramp control signals should be located and designed to minimize their viewing by mainline freeway traffic.*

12 *Regulatory signs with legends appropriate to the control, such as XX VEHICLE(S) PER GREEN or XX VEHICLE(S) PER GREEN EACH LANE (see Section 2B.61), should be installed.*

13 *When ramp control signals are installed on a freeway-to-freeway ramp, special consideration should be given to assuring adequate visibility of the ramp control signals, and multiple advance warning signs with flashing Warning Beacons should be installed to warn road users of the metered operation.*

Section 4P.03 Operation of Freeway Entrance Ramp Control Signals

Guidance:

01 *Operational strategies for ramp control signals, such as periods of operation, metering rates and algorithms, and queue management, should be determined by the operating agency prior to the installation of the ramp control signals and should be closely monitored and adjusted as needed thereafter.*

02 *When the ramp control signals are operated only during certain periods of the day, a RAMP METERED WHEN FLASHING (W3-8) sign (see Section 2C.37) should be installed in advance of the ramp control signal near the entrance to the ramp, or on the arterial on the approach to the ramp, to alert road users to the presence and operation of ramp meters.*

Standard:

03 **The RAMP METERED WHEN FLASHING sign shall be supplemented with a Warning Beacon (see Section 4S.03) that flashes when the ramp control signal is in operation (controlling the flow of traffic entering the freeway). Flashing light-emitting diode (LED) units shall not be used within the legend or border of the sign.**

CHAPTER 4Q. TRAFFIC CONTROL FOR MOVABLE BRIDGES

Section 4Q.01 Application of Traffic Control for Movable Bridges

Support:

01 Traffic signals for movable bridges are a special type of highway traffic signal installed at movable bridges to notify road users to stop because of a road closure rather than alternately controlling the flow of conflicting traffic movements. The signals are operated in coordination with the opening and closing of the movable bridge, and with the operation of movable bridge warning and resistance gates, or other devices and features used to warn, control, and stop traffic.

02 Movable bridge warning gates installed at movable bridges decrease the likelihood of vehicles and pedestrians passing the stop line and entering an area where potential hazards exist because of bridge operations.

03 A movable bridge resistance gate is sometimes used at movable bridges and located downstream of the movable bridge warning gate. A movable bridge resistance gate provides a physical deterrent to road users when placed in the appropriate position. The movable bridge resistance gates are considered a design feature and not a traffic control device; requirements for them are contained in AASHTO's "Standard Specifications for Movable Highway Bridges."

Standard:

04 **Traffic control at movable bridges shall include both signals and gates, except in the following cases:**

- **A. Neither is required if other traffic control devices or measures considered appropriate are used under either of the following conditions:**
  - **1. On low-volume roads (roads of less than 400 vehicles average daily traffic), or**
  - **2. At manually-operated bridges if electric power is not available.**
- **B. Only signals are required in urban areas if intersecting streets or driveways make gates ineffective.**
- **C. Only movable bridge warning gates are required if a traffic control signal that is controlled as part of the bridge operations exists within 500 feet of the movable bridge resistance gates and no intervening traffic entrances exist.**

Section 4Q.02 Design and Location of Movable Bridge Signals and Gates

Standard:

01 **The signal faces and mountings of movable bridge signals shall comply with the provisions of Chapters 4D through 4G except as provided in this Section.**

02 **Signal faces with 12-inch diameter signal indications shall be used for all new movable bridge signals.**

Option:

03 Existing signal faces with 8-inch diameter lenses may be retained for the remainder of their useful service life.

Standard:

04 **Since movable bridge operations cover a variable range of time periods between openings, the signal faces shall be one of the following types:**

- **A. Three-section signal faces with red, yellow, and green signal indications; or**
- **B. Two one-section signal faces with red signal indications in a vertical array separated by a STOP HERE ON RED (R10-6) sign (see Section 2B.59).**

05 **Regardless of which signal type is selected, at least two signal faces shall be provided for each approach to the movable span and a stop line (see Section 3B.19) shall be installed to indicate the point behind which vehicles are required to stop.**

Guidance:

06 *If movable bridge operation is frequent, the use of three-section signal faces should be considered.*

07 *Insofar as practicable, the height and lateral placement of signal faces should comply with the requirements for other traffic control signals in accordance with Chapter 4D. They should be located no more than 50 feet in advance of the movable bridge warning gate.*

Option:

08 Movable bridge signals may be supplemented with audible warning devices to provide additional warning to drivers and pedestrians.

Guidance:

09 *A DRAW BRIDGE (W3-6) sign (see Section 2C.36) should be used in advance of movable bridge signals and gates to give warning to road users, except in urban conditions where such signing would not be practical.*

Standard:

10 **If physical conditions prevent a road user from having a continuous view of at least two signal indications for the distance specified in Table 4D-2, an auxiliary device (either a supplemental signal face or the DRAW BRIDGE (W3-6) sign to which has been added a Warning Beacon that is interconnected with the movable bridge controller unit) shall be provided in advance of movable bridge signals and gates.**

Option:

11 The DRAW BRIDGE (W3-6) sign may be supplemented by a Warning Beacon (see Section 4S.03).

Support:

12 If two sets of gates (both a warning and a resistance gate) are used for a single direction, highway traffic signals are not required to accompany the resistance gate nearest the span opening.

Standard:

13 **Movable bridge warning gates, if used, shall be at least standard railroad size, striped with 16-inch alternate vertical, fully-reflectorized red and white stripes. Flashing red lights in accordance with the Standards for those on railroad gates (see Section 8D.03) shall be included on the gate arm and they shall only be operated if the gate is closed or in the process of being opened or closed.**

Guidance:

14 *In the horizontal position, the top of the gate should be approximately 4 feet above the pavement.*

15 *Movable bridge warning gates should be of lightweight construction. In its normal upright position, the gate arm should provide adequate lateral clearance.*

Option:

16 The movable bridge resistance gates may be delineated, if practical, in a manner similar to the movable bridge warning gate.

Guidance:

17 *Movable bridge warning gates, if used, should extend at least across the full width of the approach lanes if movable bridge resistance gates are used. On divided highways in which the roadways are separated by a barrier median, movable bridge warning gates, if used, should extend across all roadway lanes approaching the span openings.*

18 *If movable bridge resistance gates are not used on undivided highways, movable bridge warning gates, if used, should extend across the full width of the roadway.*

Option:

19 A single full-width gate or two half-width gates may be used.

Support:

20 The locations of movable bridge signals and gates are determined by the location of the movable bridge resistance gate (if used) rather than by the location of the movable spans. The movable bridge resistance gates for high-speed highways are preferably located 50 feet or more from the span opening except for bascule and lift bridges, where they are often attached to, or are a part of, the structure.

Guidance:

21 *Except where physical conditions make it impracticable, movable bridge warning gates should be located 100 feet or more from the movable bridge resistance gates or, if movable bridge resistance gates are not used, 100 feet or more from the movable span.*

22 *On bridges or causeways that cross a long reach of water and that might be hit by large marine vessels, within the limits of practicality, traffic should not be halted on a section of the bridge or causeway that is subject to impact.*

23 *In cases where it is impractical to halt traffic on a span that is not subject to impact, traffic should be halted at least one span from the opening. If traffic is halted by signals and gates more than 330 feet from the movable bridge warning gates (or from the span opening if movable bridge warning gates are not used), a second set of gates should be installed approximately 100 feet from the gate or span opening.*

24 *If the movable bridge is close to a grade crossing and traffic might possibly be stopped on the crossing as a result of the bridge opening, a traffic control device should notify the road users to not stop on the railroad tracks.*

Section 4Q.03 Operation of Movable Bridge Signals and Gates

Standard:

01 **Traffic control devices at movable bridges shall be coordinated with the movable spans, so that the signals, gates, and movable spans are controlled by the bridge tender through an interlocked control.**

02 **If the three-section type of signal face is used, the green signal indication shall be displayed at all times between bridge openings, except that if the bridge is not expected to open during continuous periods in excess of 5 hours, a flashing yellow signal indication shall be permitted to be used. The signal shall display a steady red signal indication when traffic is required to stop. The duration of the yellow change interval between the display of the green and steady red signal indications, or flashing yellow and steady red signal indications, shall be determined using engineering practices (see Section 4F.17).**

03 **If the vertical array of red signal indications is the type of signal face selected, the red signal indications shall flash alternately only when traffic is required to stop.**

Guidance:

04 *Traffic control signals on adjacent streets and highways should be interconnected with the movable bridge control if indicated by engineering judgment. When such interconnection is provided, the traffic control signals at adjacent intersections should be preempted by the operation of the movable bridge in the manner described in Section 4F.19.*

CHAPTER 4R. HIGHWAY TRAFFIC SIGNALS AT TOLL PLAZAS

Section 4R.01 Traffic Signals at Toll Plazas

Standard:

01 **Traffic control signals or devices that closely resemble traffic control signals that use red or green circular indications shall not be used at toll plazas to indicate the open or closed status of the toll plaza lanes.**

Guidance:

02 *Traffic control signals or devices that closely resemble traffic control signals that use red or green circular indications should not be used for new or reconstructed installations at toll plazas to indicate the success or failure of electronic toll payments or to alternately direct drivers making cash toll payments to stop and then proceed.*

Section 4R.02 Lane-Use Control Signals at or Near Toll Plazas

Standard:

01 **Lane-use control signals used at toll plazas shall comply with the provisions of Chapter 4T except as otherwise provided in this Section.**

02 **At toll plazas with multiple lanes where one or more lanes is sometimes closed to traffic, a lane-use control signal shall be installed above the center of each toll plaza lane to indicate the open or closed status of the controlled lane.**

Option:

03 The bottom of the signal housing of a lane-use control signal above a toll plaza lane having a canopy may be mounted lower than 15 feet above the pavement, but not lower than the vertical clearance of the canopy structure.

04 Lane-use control signals may also be used to indicate the open or closed status of an Open-Road ETC lane as a supplement to other devices used for the temporary closure of a lane (see Part 6).

Section 4R.03 Warning Beacons at Toll Plazas

Standard:

01 **Warning Beacons used at toll plazas shall comply with the provisions of Chapter 4S except as otherwise provided in this Section.**

Guidance:

02 *Warning Beacons, if used with a toll plaza canopy sign (see Section 2F.16) to assist drivers of such vehicles in locating the dedicated ETC Account-Only lane(s), should be installed in a manner such that the beacons are distinctly separate from the lane-use control signals (see Section 4T.01) for the toll plaza lane.*

Option:

03 Warning Beacons that are mounted on toll plaza islands, behind impact attenuators in front of toll plaza islands, and/or on toll booth pylons (ramparts) to identify them as objects in the roadway may be mounted at a height that is appropriate for viewing in a toll plaza context, even if that height is lower than the normal minimum of 8 feet above the pavement.

CHAPTER 4S. FLASHING BEACONS

Section 4S.01 General Design and Operation of Flashing Beacons

Support:

01 A flashing beacon is a highway traffic signal with one or more signal sections that operates in a flashing mode. It can provide traffic control when used as an intersection control beacon (see Section 4S.02) or it can provide warning when used in other applications (see Sections 4S.03, 4S.04, and 4S.05).

Standard:

02 **Flashing beacon units, their mountings, signal visors, and backplates shall comply with the provisions of Chapters 4D and 4E, except as otherwise provided in this Chapter.**

03 **Beacons shall be flashed at a rate of not less than 50 or more than 60 times per minute. The illuminated period of each flash shall be a minimum of ⅓ and a maximum of ⅔ of the total cycle.**

04 **A beacon shall not be included within the border of a sign except for Interchange Exit Direction signs with advisory speed panels (see Section 2E.25).**

05 **There shall be two nominal diameter sizes for flashing beacon signal indications: 8 inches and 12 inches.**

Guidance:

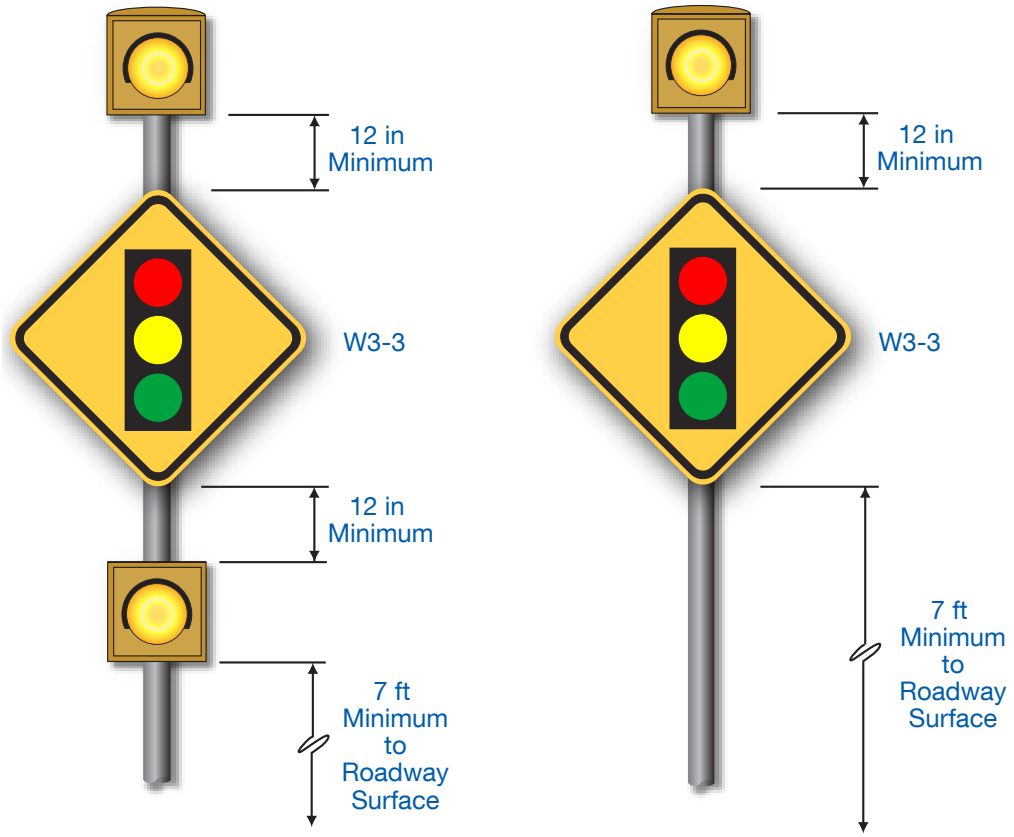
06 *If used to supplement a warning or regulatory sign, the edge of the beacon signal housing should normally be located no closer than 12 inches outside of the nearest edge of the sign or from the nearest edge of any of the signs and plaques in a sign assembly. If more than one signal section is used, the bottom beacon should be mounted at least 7 feet but not more than 8 feet above the pavement grade at the edge of the roadway (see Figures 4S-1A and 4S-2A).*

Option:

07 An automatic dimming device may be used to reduce the brilliance of flashing yellow signal indications during night operation.

08 Backplates (see Section 4D.06) may be used with flashing beacons.

Figure 4S-1A. (TX) Typical Warning Sign and Hazard Identification Beacon



Section 4S.02 Intersection Control Beacon

Standard:

01 **An Intersection Control Beacon shall consist of one or more signal faces directed toward each approach to an intersection. Each signal face shall consist of one or more signal sections of a standard traffic signal face, with flashing CIRCULAR YELLOW or CIRCULAR RED signal indications in each signal face. They shall be installed and used only at an intersection to control two or more directions of travel.**

02 **Application of Intersection Control Beacon signal indications shall be limited to the following:**

- **A. Yellow on one route (normally the major street) and red for the remaining approaches that are controlled by STOP signs, or**
- **B. Red for all approaches (if all of the intersection approaches are controlled by STOP signs).**

03 **Flashing yellow signal indications shall not face conflicting vehicular approaches.**

04 **A STOP sign (see Section 2B.04) shall be used on approaches to which a flashing red signal indication is displayed on an Intersection Control Beacon.**

05 **If two horizontally-aligned red signal indications are used on an approach for an Intersection Control Beacon, they shall be flashed simultaneously to avoid being confused with grade crossing flashing-light signals. If two vertically-aligned red signal indications that have a physical separation between them are used on an approach for an Intersection Control Beacon, they shall be flashed alternately.**

06 **Twelve-inch signal indications shall be used for Intersection Control Beacons facing approaches where:**

- **A. Road users view both Intersection Control Beacon and lane-use control signal indications simultaneously; or**
- **B. The nearest Intersection Control Beacon signal face is more than 120 feet beyond the stop line, unless a supplemental near-side Intersection Control Beacon signal face is provided.**

Guidance:

07 *Twelve-inch signal indications should be used for Intersection Control Beacons facing approaches where:*

- *A. The posted or statutory speed limit or the 85th-percentile approach speed is higher than 40 mph, or*
- *B. Where only post-mounted flashing beacon signal faces are used.*

08 *An Intersection Control Beacon should not be mounted on a pedestal in the roadway unless the pedestal is within the confines of a traffic or pedestrian island.*

Option:

09 Supplemental signal indications may be used on one or more approaches in order to provide adequate visibility to approaching road users.

10 Intersection Control Beacons may be used at intersections where traffic or physical conditions do not justify conventional traffic control signals but crash rates indicate the possibility of a special need.

11 An Intersection Control Beacon is generally located over the center of an intersection; however, it may be used at other suitable locations.

Section 4S.03 Warning Beacon

Support:

01 Typical applications of Warning Beacons include the following:

- A. As supplemental emphasis to signs or object markers on or in front of obstructions that are in or immediately adjacent to the roadway;
- B. As supplemental emphasis to warning signs;
- C. As emphasis for midblock crosswalks;
- D. As supplemental emphasis to regulatory signs, except STOP, DO NOT ENTER, WRONG WAY, and SPEED LIMIT signs; and
- E. In conjunction with a regulatory or warning sign that includes the phrase WHEN FLASHING in its legend or on a supplemental plaque to indicate that the regulation is in effect or that the condition is present only at certain times. Section 2A.12 prohibits the use flashing light-emitting diode (LED) units within the legend or border of the sign in conjunction with the phrase WHEN FLASHING in its legend or on a supplemental plaque.

Standard:

02 **A Warning Beacon shall consist of one or more signal sections of a standard traffic signal face with a flashing CIRCULAR YELLOW signal indication in each signal section (see Figure 4S-1A).**

03 **A Warning Beacon shall be used only to supplement an appropriate warning or regulatory sign or marker.**

04 **Warning Beacons, if used at intersections, shall not face conflicting vehicular approaches.**

Guidance:

05 *The condition or regulation justifying Warning Beacons should largely govern their location with respect to the roadway.*

06 *If an obstruction is in or adjacent to the roadway, illumination of the lower portion or the beginning of the obstruction or illumination of the sign on or in front of the obstruction, in addition to the beacon, should be considered.*

07 *Warning Beacons should be operated only during those periods or times when the condition or regulation exists.*

Option:

08 If Warning Beacons have more than one signal section, they may be flashed either alternately or simultaneously.

09 A Warning Beacon interconnected with a traffic signal controller assembly may be used with a BE PREPARED TO STOP (W3-4) sign and a WHEN FLASHING (W16-13P) plaque (see Section 2C.35).

10 Warning Beacons that are actuated by pedestrians, bicyclists, or other road users may be used as appropriate to provide additional warning to vehicles approaching a crossing or other location.

Guidance:

11 *An audible information device should be used with pedestrian-actuated Warning Beacons to assist pedestrians with vision disabilities.*

Standard:

12 **If an audible information device is used in conjunction with a pedestrian-actuated Warning Beacon at a pedestrian crossing, the audible information device shall not use vibrotactile indications or percussive indications.**

Guidance:

13 *If an audible information device is used in conjunction with a pedestrian-actuated Warning Beacon at a pedestrian crossing, the audible message should be a speech message that says, "Warning lights are flashing." The audible message should be spoken twice.*

Support:

14 Section 4I.05 contains further information about pedestrian push button detector location criteria and Chapter 4K contains further information on push button locator tones.

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Section 4S.04 Speed Limit Sign Beacon

Standard:

01 **A Speed Limit Sign Beacon shall be used only to supplement a Speed Limit sign.**

02 **A Speed Limit Sign Beacon shall consist of one or more signal sections of a standard traffic control signal face, with a flashing CIRCULAR YELLOW signal indication in each signal section. If two or more signal indications are used, they shall be alternately flashed.**

Option:

03 A Speed Limit Sign Beacon may be used with a fixed or variable Speed Limit sign. If applicable, a flashing Speed Limit Sign Beacon (with an appropriate accompanying sign) may be used to indicate that the displayed speed limit is in effect.

Section 4S.05 Stop Beacon

Standard:

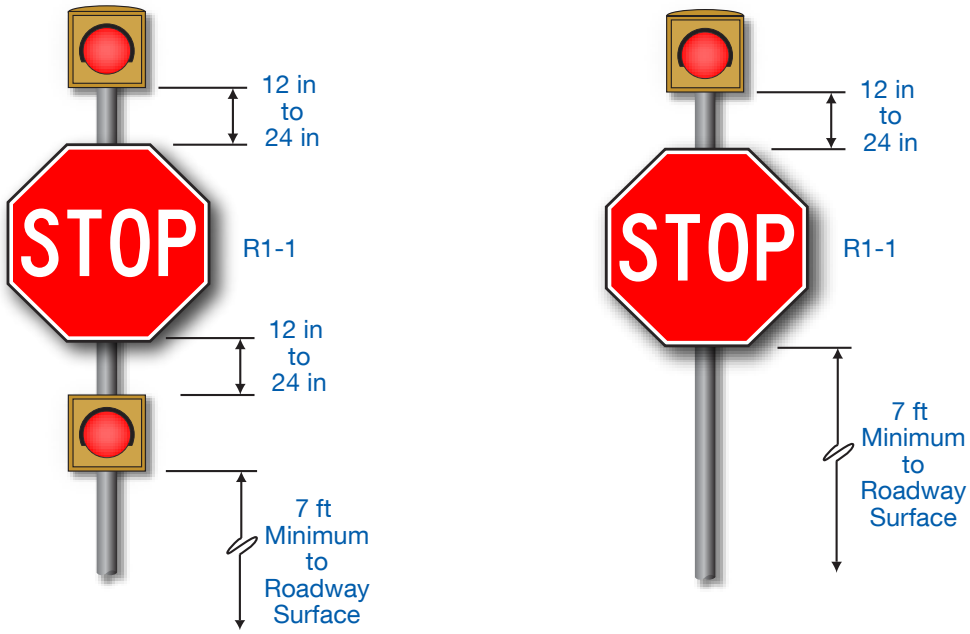
01 **A Stop Beacon shall be used only to supplement a STOP sign, a DO NOT ENTER sign, or a WRONG WAY sign.**

02 **A Stop Beacon shall consist of one or more signal sections of a standard traffic signal face with a flashing CIRCULAR RED signal indication in each signal section (see Figure 4S-2A). If two horizontally-aligned signal indications are used for a Stop Beacon, they shall be flashed simultaneously to avoid being confused with grade crossing flashing-light signals. If two vertically-aligned signal indications are used for a Stop Beacon, they shall be flashed alternately.**

Guidance:

03 *The edge of the signal housing of a Stop Beacon should be not less than 12 inches or more than 24 inches from the nearest edge of the STOP sign, DO NOT ENTER sign, or WRONG WAY sign that it supplements.*

Figure 4S-2A. (TX) Typical Stop Sign Beacon Installation at Intersection



CHAPTER 4T. LANE-USE CONTROL SIGNALS

Section 4T.01 Application of Lane-Use Control Signals

Support:

01 Lane-use control signals are special overhead signals that permit or prohibit the use of specific lanes of a street or highway or that indicate the impending prohibition of their use. Lane-use control signals are distinguished by placement of special signal faces over a certain lane or lanes of the roadway, over a shoulder where driving is permitted at certain times, and by their distinctive shapes and symbols. Supplementary signs are sometimes used to explain their meaning and intent.

02 Lane-use control signals are most commonly used for reversible lane control, but are also used in certain non-reversible-lane applications and for toll plaza lanes (see Section 4R.02).

Guidance:

03 *An engineering study should be conducted to determine whether a reversible lane operation can be controlled satisfactorily by static signs (see Section 2B.34) or whether lane-use control signals are necessary. Lane-use control signals should be used to control reversible lane operations if any of the following conditions are present:*

- *A. More than one lane is reversed in direction;*
- *B. Two-way or one-way left turns are allowed during peak-period reversible operations, but those turns are from a different lane than used during off-peak periods;*
- *C. Other unusual or complex operations are included in the reversible lane pattern;*
- *D. Demonstrated crash experience occurring with reversible lane operation controlled by static signs that can be corrected by using lane-use control signals at the times of transition between peak and off-peak patterns; and/or*
- *E. An engineering study indicates that the safety and efficiency of the traffic operations of a reversible-lane system would be improved by lane-use control signals.*

Standard:

04 **Pavement markings (see Section 3B.04) shall be used in conjunction with reversible-lane control signals.**

Option:

05 Lane-use control signals may also be used if there is no intent or need to reverse lanes, but there is a need to indicate the open or closed status of one or more lanes, such as:

- A. On a freeway, if it is desired to close certain lanes at certain hours to facilitate the merging of traffic from a ramp or other freeway;
- B. On a freeway, near its terminus, to indicate a lane that ends;
- C. On a freeway or long bridge, to indicate that a lane may be temporarily blocked by a crash, breakdown, construction or maintenance activities, or similar temporary conditions; and
- D. On a conventional road or driveway, at access or egress points to or from a facility, such as a parking garage, where one or more lanes of the access or egress are opened or closed at various times.

06 A USE LANE(S) WITH GREEN ARROW (R10-8) sign (see Section 2B.59) may be used in conjunction with lane-use control signals.

Section 4T.02 Meaning of Lane-Use Control Signal Indications

Standard:

01 **The meanings of lane-use control signal indications (see Figure 4T-1) shall be as follows:**

- **A. A steady DOWNWARD GREEN ARROW signal indication shall mean that the lane which the arrow signal indication is located over is open to vehicle travel in that direction.**
- **B. A steady YELLOW X signal indication shall mean that the lane which the Yellow X signal indication is located over is about to be closed to vehicle traffic in that direction and shall be followed by a steady RED X signal indication (either within the same signal face or in a downstream signal face).**
- **C. A steady RED X signal indication shall mean that the lane which the Red X signal indication is located over is closed to vehicle traffic in the direction viewed by the road user.**

D. A steady WHITE TWO-WAY LEFT-TURN ARROW signal indication shall mean that the lane which the turning arrows indication is located over is open to traffic making a left turn from either direction of travel, but not for through travel.

E. A steady WHITE ONE-WAY LEFT-TURN ARROW signal indication shall mean that the lane which the turning arrow indication is located over is open to traffic making a left turn in that direction (without opposing turns in the same lane), but not for through travel.

Figure 4T-1. Lane-Use Control Signal Indications



Downward Green Arrow | Yellow X | Red X | White Two-Way Left-Turn Arrows | White One-Way Left-Turn Arrow

Section 4T.03 Design of Lane-Use Control Signals

Standard:

01 **All lane-use control signal indications shall be in units with rectangular signal faces and shall have opaque backgrounds. Except as provided in Paragraph 13 of this Section, the nominal minimum height and width of each DOWNWARD GREEN ARROW, YELLOW X, and RED X signal face shall be 18 inches for typical applications. Except as provided in Paragraph 13 of this Section, the WHITE TWO-WAY LEFT-TURN ARROW and WHITE ONE-WAY LEFT-TURN ARROW signal faces shall have a nominal minimum height and width of 30 inches.**

02 **Each lane to be reversed or closed shall have signal faces with at least a DOWNWARD GREEN ARROW and a RED X symbol.**

03 **Each reversible-lane that also operates as a two-way or one-way left-turn lane during certain periods shall have signal faces that also include the applicable WHITE TWO-WAY LEFT-TURN ARROW or WHITE ONE-WAY LEFT-TURN ARROW symbol.**

04 **Each non-reversible-lane immediately adjacent to a reversible-lane shall have signal indications that display a DOWNWARD GREEN ARROW to traffic traveling in the permitted direction and a RED X to traffic traveling in the opposite direction.**

05 **If in separate signal sections, the relative positions, from left to right, of the signal indications shall be RED X, YELLOW X, DOWNWARD GREEN ARROW, WHITE TWO-WAY LEFT-TURN ARROW, WHITE ONE-WAY LEFT-TURN ARROW.**

Guidance:

06 *The color of lane-use control signal indications should be clearly visible for at least 2,300 feet at all times under normal atmospheric conditions, unless otherwise physically obstructed.*

07 *Lane-use control signal faces should be located approximately over the center of the controlled lane.*

08 *If the area to be controlled is more than 2,300 feet in length, or if the vertical or horizontal alignment is curved, intermediate lane-use control signal faces should be located over each controlled lane at frequent intervals. This location should be such that road users will at all times be able to see at least one signal indication and preferably two along the roadway, and will have a definite indication of the lanes specifically reserved for their use.*

09 *All lane-use control signal faces should be located in a straight line across the roadway approximately at right angles to the roadway alignment.*

10 *On roadways having intersections controlled by traffic control signals, the lane-use control signal face should be located sufficiently far in advance of or beyond such traffic control signals to prevent them from being misconstrued as traffic control signals.*

Standard:

11 **Except as provided in Paragraph 12 of this Section, the bottom of the signal housing of any lane-use control signal face shall be a minimum of 15 feet and a maximum of 19 feet above the pavement grade.**

Option:

12 The bottom of a lane-use control signal housing may be lower than 15 feet above the pavement if it is mounted on a canopy or other structure over the pavement, but not lower than the vertical clearance of the structure.

13 Except for lane-use control signals at toll plazas (see Section 4R.02), lane-use control signal faces with nominal height and width of 12 inches for the DOWNWARD GREEN ARROW, YELLOW X, and RED X signal faces, and lane-use control signal faces with nominal height and width of 18 inches for the WHITE TWO-WAY LEFT-TURN ARROW and WHITE ONE-WAY LEFT-TURN ARROW signal faces may be used in areas with minimal visual clutter and with speeds of less than 40 mph.

14 Other sizes of lane-use control signal faces larger than 18 inches with proportional dimensions and with message recognition distances appropriate to signal spacing may be used for the DOWNWARD GREEN ARROW, YELLOW X, and RED X signal faces.

15 Non-reversible lanes not immediately adjacent to a reversible lane on any street so controlled may also be provided with signal indications that display a DOWNWARD GREEN ARROW to traffic traveling in the permitted direction and a RED X to traffic traveling in the opposite direction.

16 The signal indications provided for each lane may be in separate signal sections or may be superimposed in the same signal section.

Section 4T.04 Operation of Lane-Use Control Signals

Standard:

01 **All lane-use control signals shall be coordinated so that all the signal indications along the controlled section of roadway are operated uniformly and consistently. The lane-use control signal system shall be designed to reliably guard against showing any prohibited combination of signal indications to any traffic at any point in the controlled lanes.**

02 **For reversible lane control signals, the following combination of signal indications shall not be simultaneously displayed over the same lane to both directions of travel:**

- **A. DOWNWARD GREEN ARROW in both directions,**
- **B. YELLOW X in both directions,**
- **C. WHITE ONE-WAY LEFT-TURN ARROW in both directions,**
- **D. DOWNWARD GREEN ARROW in one direction and YELLOW X in the other direction,**
- **E. WHITE TWO-WAY LEFT-TURN ARROW or WHITE ONE-WAY LEFT-TURN ARROW in one direction and DOWNWARD GREEN ARROW in the other direction,**
- **F. WHITE TWO-WAY LEFT-TURN ARROW in one direction and WHITE ONE-WAY LEFT-TURN ARROW in the other direction, and**
- **G. WHITE ONE-WAY LEFT-TURN ARROW in one direction and YELLOW X in the other direction.**

03 **A moving condition in one direction shall be terminated either by the immediate display of a RED X signal indication or by a YELLOW X signal indication followed by a RED X signal indication.**

04 **In either case, the duration of the RED X signal indication shall be an appropriate duration to allow traffic time to vacate the lane before any moving condition is allowed in the opposing direction.**

05 **Whenever a DOWNWARD GREEN ARROW signal indication is changed to a WHITE TWO-WAY LEFT-TURN ARROW signal indication, the RED X signal indication shall continue to be displayed to the opposite direction of travel for an appropriate duration to allow traffic time to vacate the lane being converted to a two-way left-turn lane.**

06 **If an automatic control system is used, a manual control to override the automatic control shall be provided.**

Guidance:

07 *The type of control provided for reversible lane operation should be such as to permit either automatic or manual operation of the lane-use control signals.*

Standard:

08 **If used, lane-use control signals shall be operated continuously, except that lane-use control signals that are used only for special events or other infrequent occurrences and lane-use control signals on non-reversible freeway lanes are permitted to be darkened when not in operation. The change from normal operation to non-operation shall occur only when the lane-use control signals display signal indications**

that are appropriate for the lane use that applies when the signals are not operated. The lane-use control signals shall display signal indications that are appropriate for the existing lane use when changed from non-operation to normal operations. Also, traffic control devices shall clearly indicate the proper lane use when the lane-use control signals are not in operation.

Support:

09 Section 2B.34 contains additional information concerning considerations involving left-turn prohibitions in conjunction with reversible lane operations. Section 2G.24 contains additional information concerning lane-use control signals used for part-time travel on a shoulder. Section 2G.25 contains additional information concerning lane-use control signals used for active lane management on freeways and expressways.

CHAPTER 4U. IN-ROADWAY WARNING LIGHTS

Section 4U.01 Application of In-Roadway Warning Lights

Support:

01 In-Roadway Warning Lights are special types of highway traffic signals installed in the roadway surface to warn road users that they are approaching a condition on or adjacent to the roadway that might not be readily apparent and might require the road users to reduce their speed and/or come to a stop. This includes situations warning of marked school crosswalks, marked midblock crosswalks, marked crosswalks on uncontrolled approaches, marked crosswalks in advance of roundabouts as described in Chapter 3D, and other roadway situations involving pedestrian crossings.

Standard:

02 **In-Roadway Warning Lights shall not be used for any application that is not described in this Chapter.**

03 **When used, In-Roadway Warning Lights shall be flashed and shall not be steadily illuminated.**

Support:

04 Steadily illuminated lights installed in the roadway surface are considered to be internally illuminated raised pavement markers (see Section 3B.14).

Option:

05 In-Roadway Warning Lights may be flashed in a manner that includes a continuous flash of varying intensity and time duration that is repeated to provide a flickering effect (see Section 4U.02).

Guidance:

06 *If used, In-Roadway Warning Lights should not exceed a height of ¾ inch above the roadway surface.*

Section 4U.02 In-Roadway Warning Lights at Crosswalks

Option:

01 In-Roadway Warning Lights may be installed at certain marked crosswalks, based on an engineering study or engineering judgment, to provide additional warning to road users.

Standard:

02 **If used, In-Roadway Warning Lights at crosswalks shall be installed only at marked crosswalks with applicable warning signs. They shall not be used at crosswalks controlled by YIELD signs, STOP signs, traffic control signals, or pedestrian hybrid beacons.**

03 **If In-Roadway Warning Lights are used at a crosswalk, the following requirements shall apply:**

- **A. Except as provided in Paragraphs 8 and 9 of this Section, they shall be installed along both sides of the crosswalk and shall span its entire length.**
- **B. They shall initiate operation based on pedestrian actuation and shall cease operation at a predetermined time after the pedestrian actuation or, with passive detection, after the pedestrian clears the crosswalk.**
- **C. They shall display a flashing yellow light when actuated. The flash rate shall be at least 50, but not more than 60, flash periods per minute. If they are flashed in a manner that includes a continuous flash of varying intensity and time duration that is repeated to provide a flickering effect, the flickers or pulses shall not repeat at a rate that is between 5 and 30 per second to avoid frequencies that might cause seizures.**
- **D. They shall be installed in the area between the outside edge of the crosswalk line and 10 feet from the outside edge of the crosswalk.**
- **E. They shall face away from the crosswalk if unidirectional, or shall face away from and across the crosswalk if bidirectional.**

04 **If used on one-lane, one-way roadways, a minimum of two In-Roadway Warning Lights shall be installed on the approach side of the crosswalk. If used on two-lane roadways, a minimum of three In-Roadway Warning Lights shall be installed along both sides of the crosswalk. If used on roadways with more than two lanes, a minimum of one In-Roadway Warning Light per lane shall be installed along both sides of the crosswalk.**

Guidance:

05 *If used, In-Roadway Warning Lights should be installed in the center of each travel lane, at the center line of the roadway, at each edge of the roadway or parking lanes, or at other suitable locations away from the normal tire track paths.*

06 *The location of the In-Roadway Warning Lights within the lanes should be based on engineering judgment.*

Option:

07 On one-way streets, In-Roadway Warning Lights may be omitted on the departure side of the crosswalk.

08 Based on engineering judgment, the In-Roadway Warning Lights on the departure side of the crosswalk on the left-hand side of a median may be omitted.

09 Unidirectional In-Roadway Warning Lights installed at crosswalk locations may have an optional, additional yellow light indication in each unit that is visible to pedestrians in the crosswalk to indicate to pedestrians in the crosswalk that the In-Roadway Warning Lights are in fact flashing as they cross the street. These yellow lights may flash with and at the same flash rate as the light module in which each is installed.

Guidance:

10 *If used, the period of operation of the In-Roadway Warning Lights following each actuation should be sufficient to allow a pedestrian crossing in the crosswalk to leave the curb or shoulder and travel at a walking speed of 3.5 feet per second to at least the far side of the traveled way or to a median of sufficient width for pedestrians to wait. Where pedestrians who walk slower than 3.5 feet per second, or pedestrians who use wheelchairs, routinely use the crosswalk, a walking speed of less than 3.5 feet per second should be considered in determining the period of operation.*

11 *An audible information device should be used with In-Roadway Warning Lights to provide assistance for pedestrians with vision disabilities.*

Standard:

12 **If pedestrian push buttons (rather than passive detection) are used to actuate the In-Roadway Warning Lights, a PUSH BUTTON FOR WARNING LIGHTS/AWAIT GAP IN TRAFFIC (R10-25) sign (see Section 2B.58) shall be installed explaining the purpose and use of the pedestrian push button detector.**

13 **Where the period of operation is sufficient only for crossing from a curb or shoulder to a median of sufficient width for pedestrians to wait, median-mounted pedestrian actuators shall be provided.**

14 **If an audible information device is used in conjunction with In-Roadway Warning Lights, the audible information device shall not use vibrotactile indications or percussive indications.**

Guidance:

15 *If an audible information device is used in conjunction with In-Roadway Warning Lights, the audible message during the time that the lights are flashing should be a speech message that says, "Warning lights are flashing." The audible message should be spoken twice.*

Support:

Rev. 1

16 Section 4I.05 contains further information about pedestrian push button detector location criteria and Chapter 4K contains further information on push button locator tones.