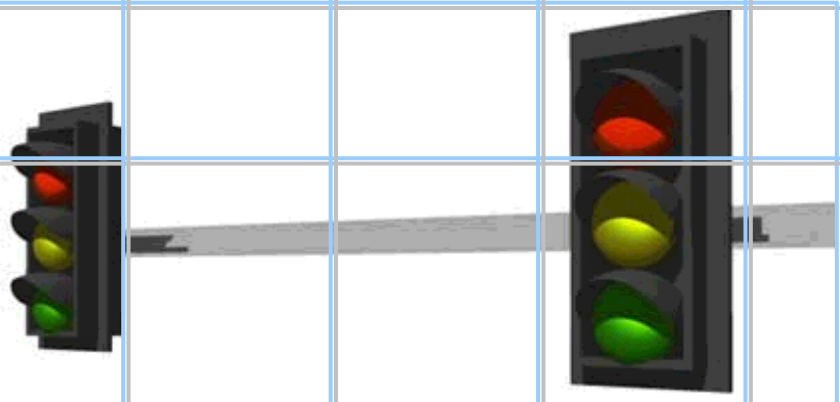
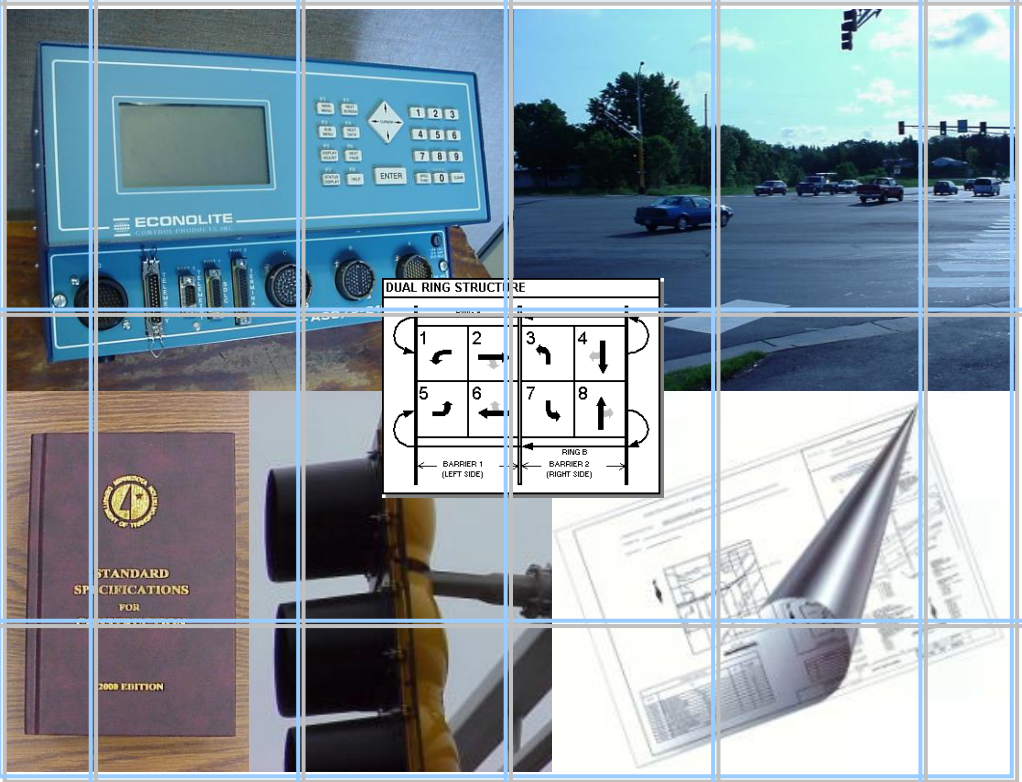
MnDOT - Office of Traffic, Safety & Technology (OTST)



Traffic Signals 101



January 2018

This book belongs to:

DEPARTMENT OF TRANSPORTATION

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2018 Traffic Signals 101

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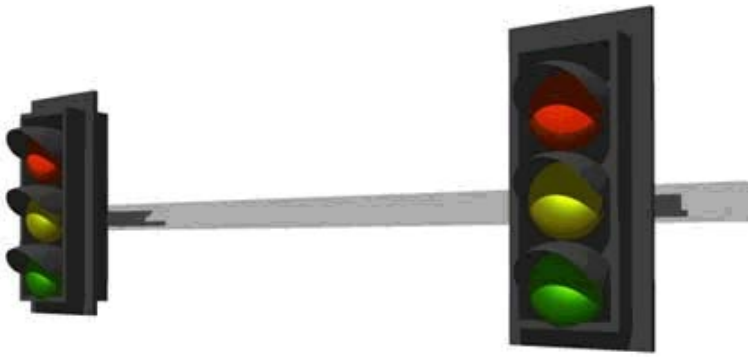

DEPARTMENT OF TRANSPORTATION

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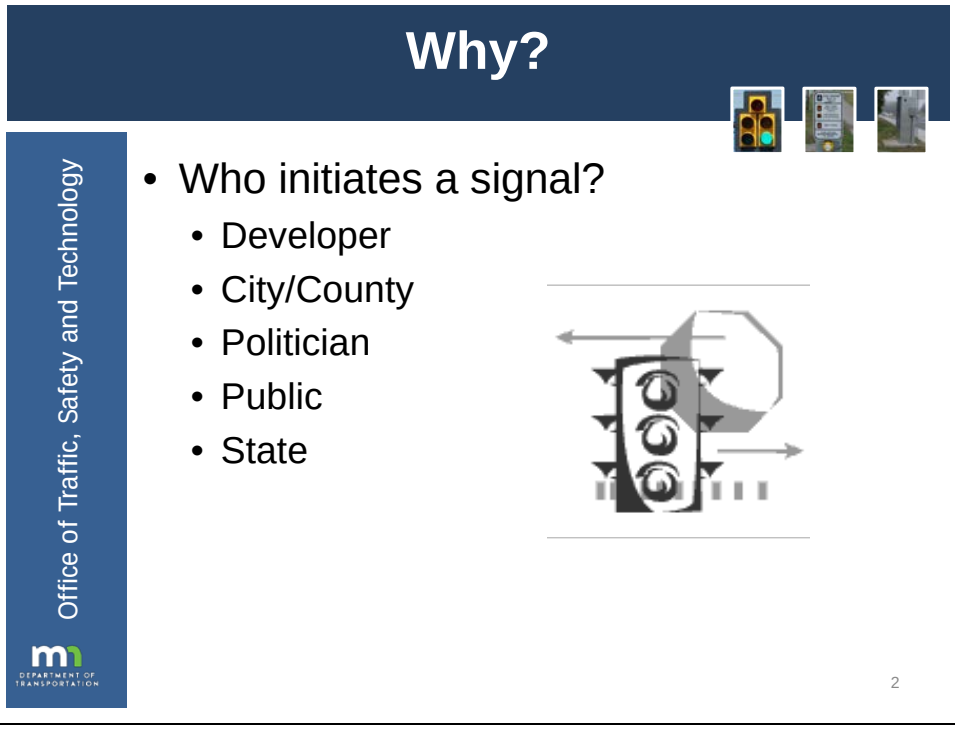
TOPIC 1: WHY?

This chapter will address the issue as to why a traffic signal is installed. This includes:

- Who initiates a signal
- Traffic Signal Warrants
- Intersection Control Evaluation (ICE) Reports
- Associated Manuals

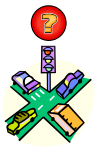


A signal may be initiated in many ways. If a study shows such a signal is justified, then the signal must be programmed, that is, budgeted for and put into the letting schedule.

Why?

Office of Traffic, Safety and Technology

- Signal Warrants
  - Traffic control signals should not be installed unless one or more of the signal warrants in the MN MUTCD are met
  - The satisfaction of a warrant or warrants is not in itself justification for a signal
  - Information should be obtained by means of engineering studies and compared with the requirements set forth in the warrants
  - An Intersection Control Evaluation report needs to be prepared (see slide 8)



3

Traffic signal warrants are found in the Minnesota Manual on Uniform Traffic Control Devices (MN MUTCD), Chapter 4C, December 2011 (often referred to as the "MUTT").

In addition to meeting a warrant, to be justified a signal should meet perceived safety or operational needs.

An Intersection Control Evaluation (ICE) report is required. Details are found later in this section.

Why?

Office of Traffic, Safety and Technology

- **Signal Warrants**
  - Warrant 1 - Eight-Hour Vehicular Volume
  - Warrant 2 - Four-Hour Vehicular Volume
  - Warrant 3 - Peak Hour
  - Warrant 4 - Pedestrian Volume

4

There are nine (9) warrants contained in the MN MUTCD.

A detailed description of these warrants is included at the end of this topic as a handout. This information is a printout of Chapter 4C of the MN MUTCD and can be found on the Office of Traffic, Security & Technology web site. Please visit the website listed at the bottom of this page for the most current version of the MN MUTCD.

Office of Traffic, Security & Technology publications website:
www.dot.state.mn.us/trafficeng/publ/index.html

Why?

Office of Traffic, Safety and Technology

- **Signal Warrants**
  - Warrant 5 - School Crossing
  - Warrant 6 - Coordinated Signal System
  - Warrant 7 - Crash Experience
  - Warrant 8 - Roadway Network
  - Warrant 9 - Intersection Near a Grade Crossing

5

Other warrants are less strong, and require careful justification to avoid placing signals that cause more problems than they solve.

For instance, consider Warrant 3. If only one hour is met for Warrant 3, then a signal could be installed that is only needed 1 hour our of 24 hours (on a weekday).

Another example is Warrant 7. Note that the language states “Five or more reported crashes, of types susceptible to correction by a traffic control signal, …”. A rear-end collision is not considered to be an accident that could be corrected by a signal (in fact, this type often increases).

Why?

Office of Traffic, Safety and Technology

- Warrant 1 Example
  - The Minimum Vehicular Volume, Condition A, is intended for application at locations where a large volume of intersecting traffic is the principal reason to consider installing a traffic control signal
  - The Interruption of Continuous Traffic, Condition B, 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

Warrant 1 tables

6

Warrant 1 requires at a minimum eight hours of traffic data. To meet warrant 1, at least eight distinct hours must meet the threshold volumes.

Why?

Office of Traffic, Safety and Technology

Condition A - Minimum Vehicle Volume										
Number of lanes for moving traffic on each approach		Vehicles per hour on major street (total of both approaches)				Vehicles per hour on higher-volume 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	

Time	Vehicles Per Hour: Total of Both Major Street. Approaches	Vehicles Per Hour: Higher Minor Street Approach	Minimum Required: Total of Both Major Street. Approaches	Minimum Required: Higher Minor Street Approach	Hour Satisfied?
6:00 to 7:00	650	205	600	200	Yes
7:00 to 8:00	690	250	600	200	Yes
8:00 to 9:00	640	201	600	200	Yes
9:00 to 10:00	600	190	600	200	No
10:00 to 11:00	550	100	600	200	No
11:00 to 12:00	560	120	600	200	No
12:00 to 1:00	600	160	600	200	No
1:00 to 2:00	590	130	600	200	No
2:00 to 3:00	580	180	600	200	No
3:00 to 4:00	600	190	600	200	No
4:00 to 5:00	630	220	600	200	Yes
5:00 to 6:00	700	250	600	200	Yes
6:00 to 7:00	680	230	600	200	Yes
7:00 to 8:00	550	200	600	200	No
8:00 to 9:00	450	190	600	200	No
9:00 to 10:00	400	100	600	200	No

Warrant not met for Condition A (6 of 8 hours met)

7

To be warranted, one of the following must occur:

1. Condition A or B is met for at least 8 hours a day as shown on the 100% column
2. Condition A or B is met for at least 8 hours a day as shown on the 70% column if the posted or 85th percentile speed on the mainline exceeds 40 MPH or the intersection lies within the built-up area of an isolated community having a population of less than 10,000.

This example only looks at Condition A.

Why?

Office of Traffic, Safety and Technology

- Intersection Control Evaluation (ICE)
  - In the past, the only perceived solution to traffic delay and safety problems for at-grade intersections was the installation of a traffic signal
    - Based on Signal Justification Reports (SJR)
  - Other options including stop control, roundabouts, and unconventional reduced-access intersections, may be acceptable alternatives

ICE Book

8

Previously, Signal Justification Reports (SJR's) must have been completed before a new signal or significant modification of a signal could proceed (MN MUTCD and MnDOT Traffic Engineering Manual updated July 1, 2003). The SJR is straight-forward but does not consider other alternatives.

Why?

Office of Traffic, Safety and Technology

- ICE Definition
  - Intersection Control Evaluation, or ICE, is a process that identifies the **best** intersection control through a comprehensive analysis and documentation of the technical (safety and operational), economic, and political issues of viable alternatives

9

Why?

Office of Traffic, Safety and Technology

- Purpose of ICE
  - Evaluate various intersection designs
  - Select the optimal control for an intersection based on an objective analysis for the existing conditions and future needs
  - Document all technical, financial, and political issues in the ICE Report
    - Replaces the SJR

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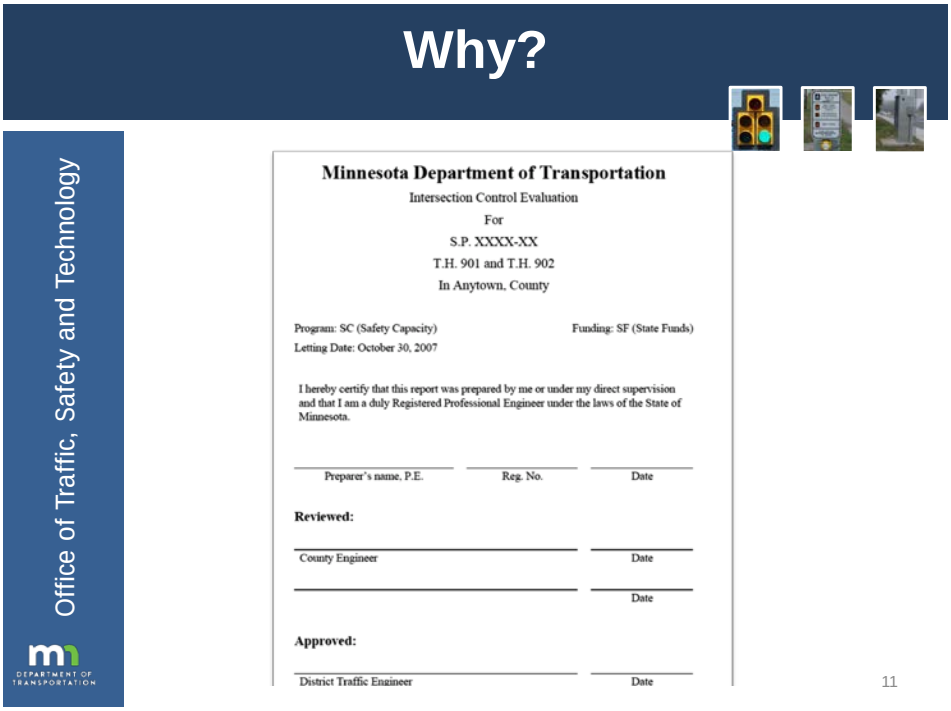
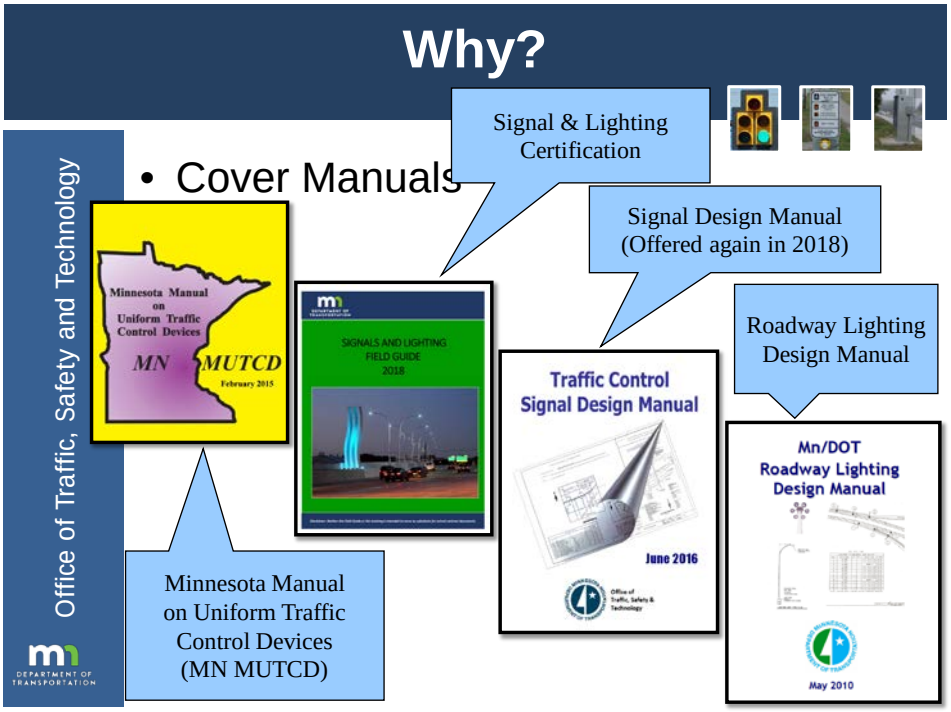


The image on the slide is a sample ICE report cover sheet. The ICE report must be completed under the direct supervision of a Minnesota Professional Engineer (PE). The ICE report is also to be reviewed by appropriate agencies and approved by the District Traffic Engineer (DTE).

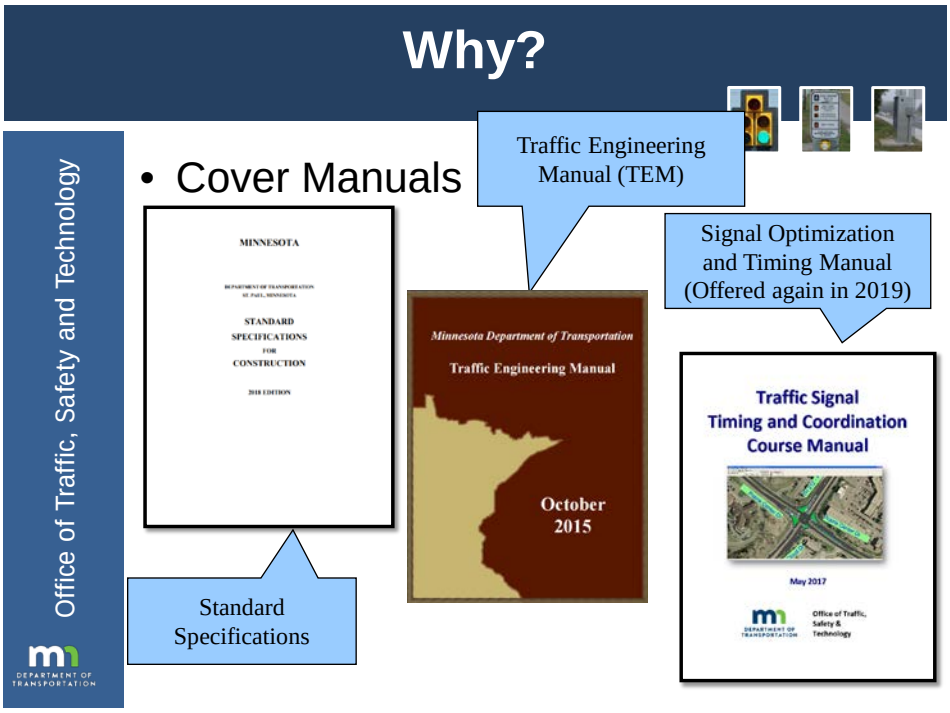


The MN MUTCD is the Minnesota Manual of Uniform Traffic Control Devices. It contains the warrants for traffic signals.

The Signal and Light Certification course Workshop offered by MnDOT covers the "nuts and bolts" of signals and lighting.

The Signal Design Manual covers the design of signal systems. It is a prerequisite for how to design a traffic system.

The Lighting Design Manual covers the design of roadway lighting systems.



The Standard Specifications are used for all types of construction. Refer to Topic 13 of this workbook for more details.

The Traffic Engineering Manual (TEM) contains a variety of information related to signals.

The Signal Optimization and Timing Manual is a manual for how to run and operate a traffic signal and signal system.

Visit the Office of Traffic, Security & Technology website for up-to-date publications (including this manual).

Visit the Office of Traffic, Security & Technology (OTST) website for a wide range of up-to-date resources.

Many of the references used in this Manual can be downloaded via the Publications link.

Handout

Excerpts from MN MUTCD (Page 4C-1 to 4C-13)

For the latest version of the MN MUTCD, please visit:

www.dot.state.mn.us/trafficeng/publ/mutcd/index.html

PART 4. HIGHWAY TRAFFIC SIGNALS

Chapter 4C. Traffic Control Signal Needs Studies

4C.1 Studies and Factors for Justifying Traffic Control Signals

STANDARD:

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 a particular location.

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

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

SUPPORT:

Sections 8D.9 and 8C.10 contain information regarding the use of traffic control signals instead of gates and/or flashing light signals at highway-rail grade crossings and highway-light rail transit grade crossings, respectively.

GUIDANCE:

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

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.

A traffic control signal should not be installed if it will seriously disrupt progressive traffic flow.

The study should consider the effects of the right-turn vehicles from the minor-street approaches. Engineering judgment should be used to determine what, if any, portion of the right-turn traffic is subtracted from the minor-street traffic count when evaluating the count against the above signal warrants.

Engineering judgment should also be used in applying various traffic signal warrants to cases where approaches consist of one lane plus one left-turn or right-turn lane. The site-specific traffic characteristics should dictate whether an approach is considered as one lane or two lanes. For example, for an 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 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-turn vehicles.

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

At a location that is under development or construction and 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 stop-and-go operation to determine if the signal is justified. If not justified, the signal should be taken out of stop-and-go operation or removed.

For signal warrant analysis, a location with a wide median, even if the median width is greater than 30 feet, should be considered as one intersection.

OPTION:

At an intersection with a high volume of left-turn 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.

For signal warrants requiring conditions to be present for a certain number of hours in order to be satisfied, any four sequential 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 one-hour periods.

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

SUPPORT:

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:

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 total traffic entering the intersection is greatest.
C. Pedestrian volume counts on each crosswalk during the same periods as the vehicular counts in Item B and during hours of highest pedestrian volume. Where young, elderly, and/or persons with physical or visual 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 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.

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 the preceding paragraph:

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.

4C.2 Warrant 1, Eight-Hour Vehicular Volume

SUPPORT:

The Minimum Vehicular Volume, Condition A, is intended for application at locations where a large volume of intersecting traffic is the principal reason to consider installing a traffic control signal.

The Interruption of Continuous Traffic, Condition B, 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.

It is intended that Warrant 1 be treated as a single warrant. If Condition A is satisfied, then Warrant 1 is satisfied and analysis 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.

STANDARD:

The need for a traffic control signal shall 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 higher-volume minor-street approaches, respectively, to the intersection; or
B. The vehicles per hour given in both of the 100 percent

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 higher-volume 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 higher-volume 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 m ajor-street speed exceeds 40 mph or in an isolated community with a population of less than 10,000.

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

columns of Condition B in Table 4C-1 exist on the major-street and the higher-volume minor-street approaches, respectively, to the intersection.

In applying each condition the major-street and minor-street volumes shall be for the same 8 hours. On the minor street, the higher volume shall not be required to be on the same approach during each of these 8 hours.

OPTION:

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.

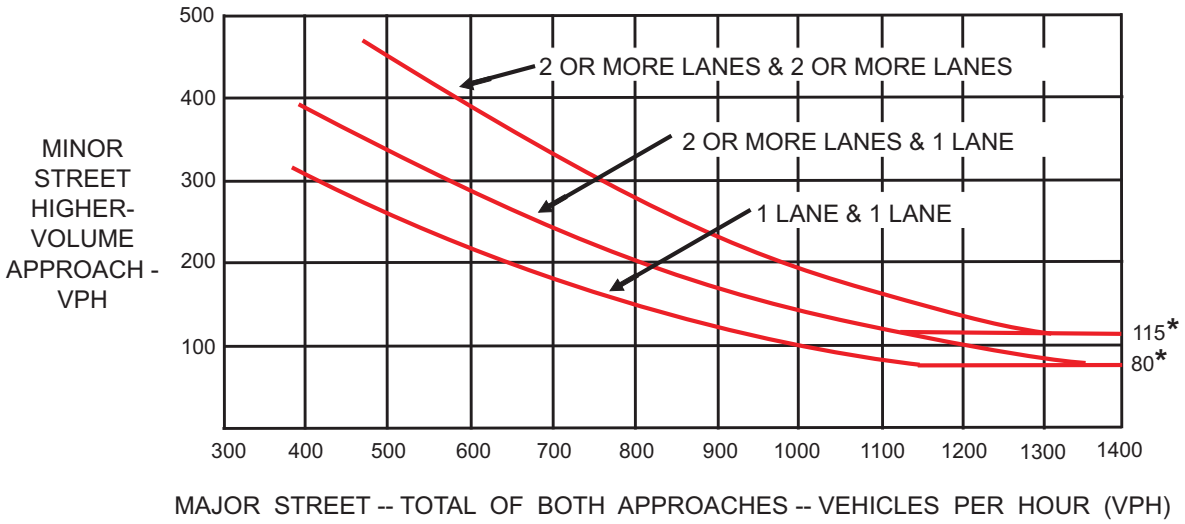
GUIDANCE:

The combination of Conditions A and B 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.

STANDARD:

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

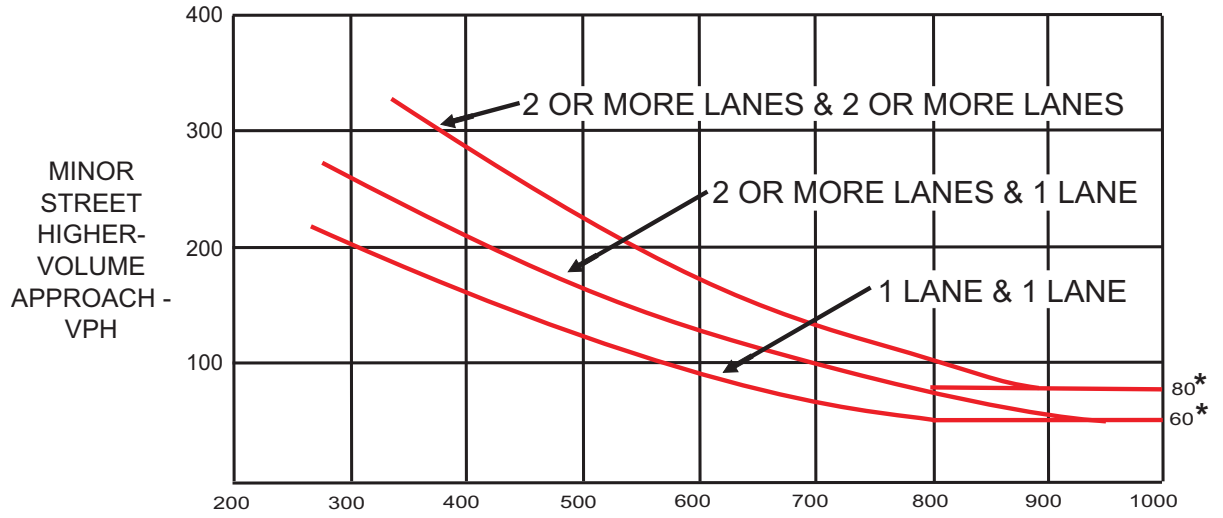
A. The vehicles per hour given in both of the 80 percent columns of Condition A in Table 4C-1 exist on the major-street and the higher-volume minor-street approaches, respectively, to the intersection; and



*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-1. Warrant 2 - Four-Hour Vehicular Volume

(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.

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

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 higher-volume minor-street approaches, respectively, to the intersection.

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. On the minor street the higher volume shall not be required to be on the same approach during each of the 8 hours.

OPTION:

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.

4C.3 Warrant 2, Four-Hour Vehicular Volume

SUPPORT:

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.

STANDARD:

The need for a traffic control signal shall 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 higher-volume minor-street approach (one direction only) all fall above the applicable curve in Figure 4C-1 for the existing combination of approach lanes. On the minor street, the higher volume shall not be required to be on the same approach during each of these 4 hours.

OPTION:

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.

4C.4 Warrant 3, Peak Hour

SUPPORT:

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.

STANDARD:

This signal warrant shall be applied only in unusual cases. Such cases include, but are not limited to, office complexes, manufacturing plants, industrial complexes, or high-occupancy vehicle facilities that attract or discharge large numbers of vehicles over a short time.

The need for a traffic control signal shall 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 higher-volume 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.

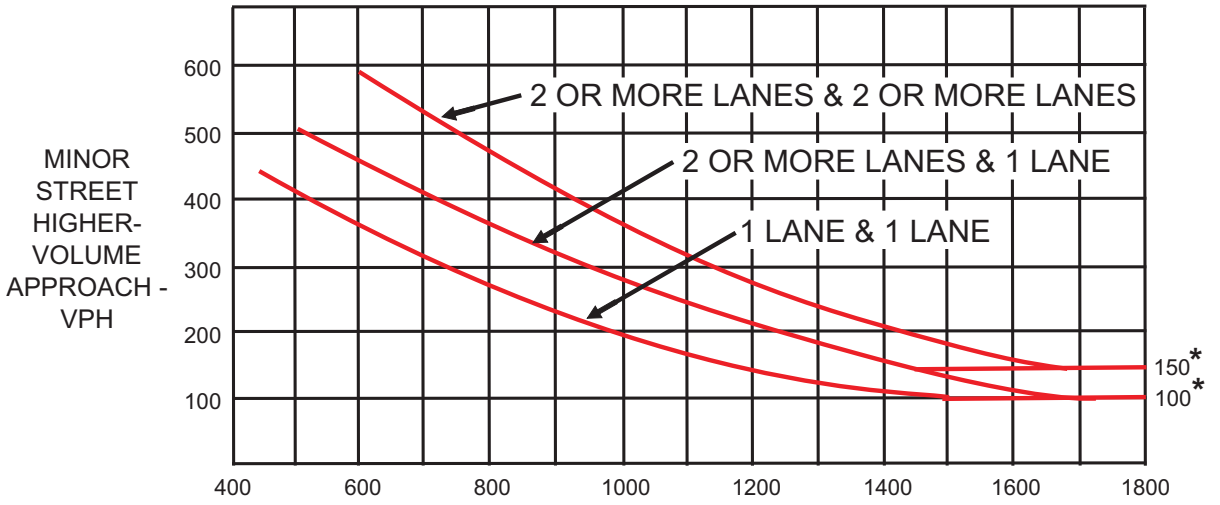
OPTION:

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 satisfy the criteria in the second category of the Standard.

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:

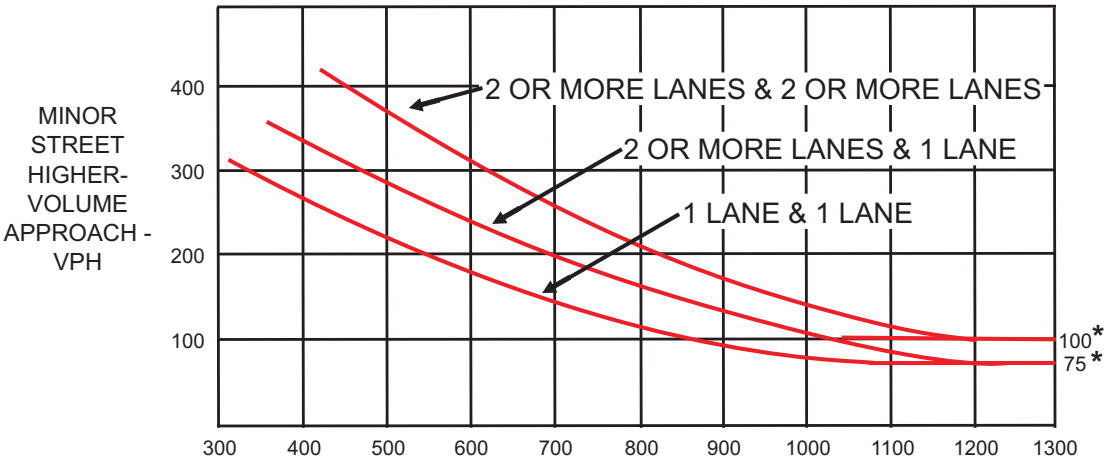
If this warrant is the only warrant met and a traffic control signal is justified by an engineering study, the traffic control signal should be traffic-actuated.



*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-3. Warrant 3 - Peak Hour

(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.

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

4C.5 Warrant 4, Pedestrian Volume

SUPPORT:

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.

STANDARD:

The need for a traffic control signal at an intersection or mid-block crossing shall 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-7.

OPTION:

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-6 may be used in place of Figure 4C-5 to evaluate Criterion A above and Figure 4C-8 may be used in place of Figure 4C-7 to evaluate Criterion B above.

STANDARD:

The Pedestrian Volume signal warrant shall 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.

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 4E.

GUIDANCE:

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 series of signals, the traffic control signal should be coordinated.

OPTION:

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 ft/sec.

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.

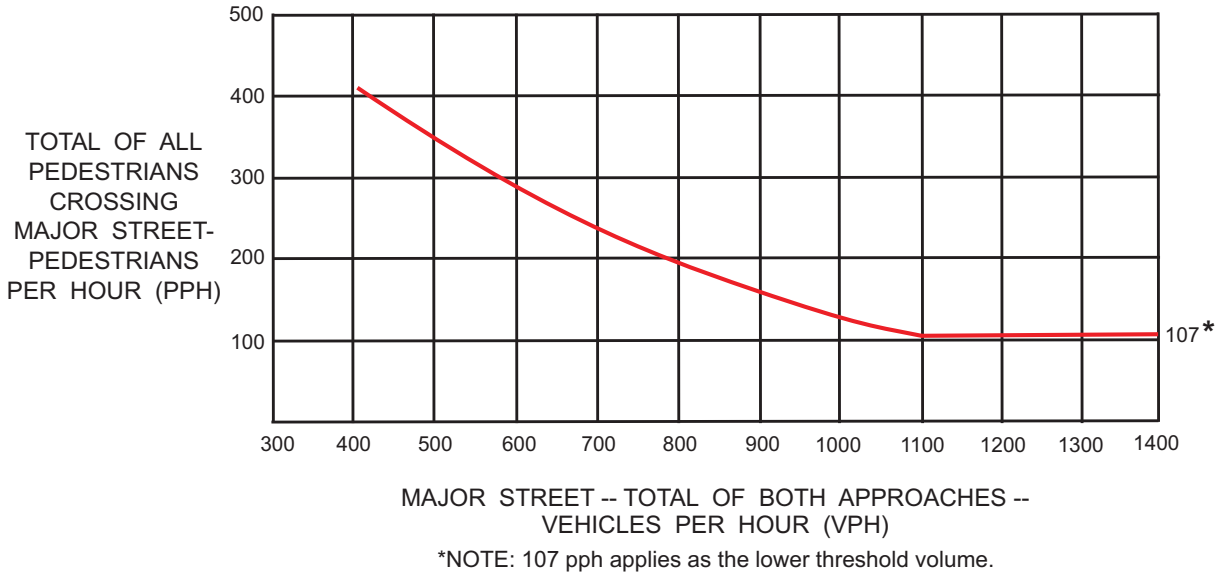
4C.6 Warrant 5, School Crossing

SUPPORT:

The School Crossing signal warrant is intended for application where the fact that school children 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.

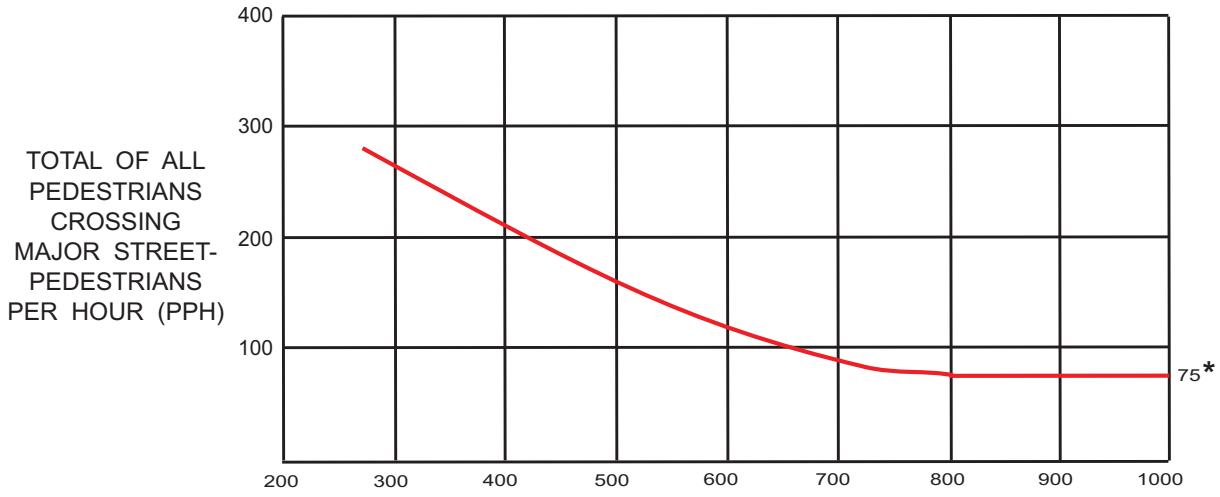
STANDARD:

The need for a traffic control signal shall 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 (see Section 7A.3) and there are a minimum of 20 schoolchildren during the highest crossing hour.



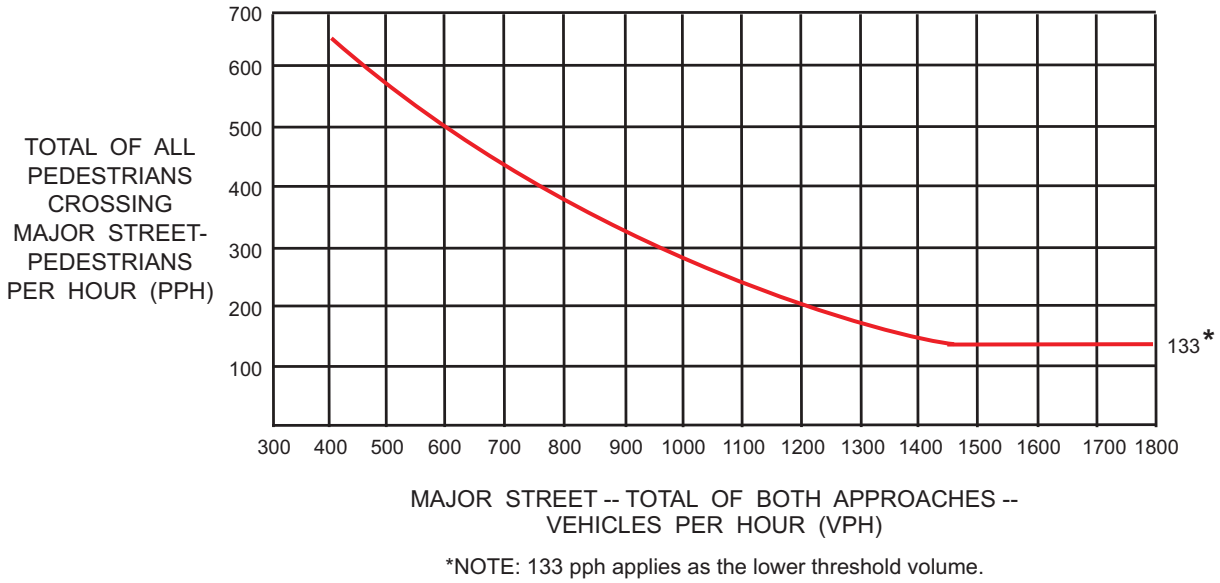
*NOTE: 107 pph applies as the lower threshold volume.

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



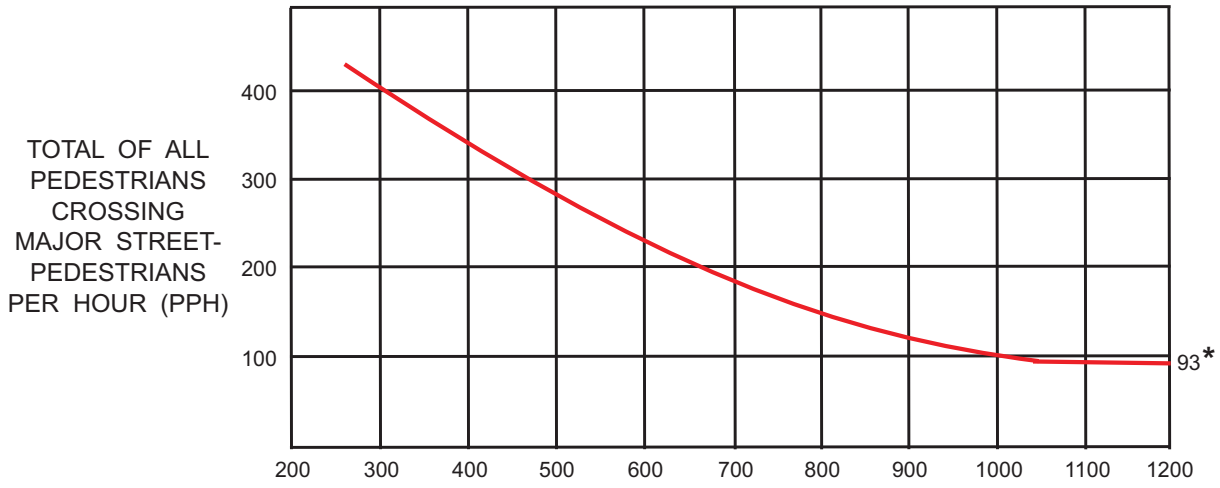
*NOTE: 75 pph applies as the lower threshold volume.

Figure 4C-6. Warrant 4 - Pedestrian Four-Hour Volume (70% Factor)



*NOTE: 133 pph applies as the lower threshold volume.

Figure 4C-7. Warrant 4 - Pedestrian Peak Hour



*NOTE: 93 pph applies as the lower threshold volume.

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

Before a decision is made to install a traffic control signal, consideration shall 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.

The School Crossing signal warrant shall not be applied at locations where the distance to the nearest traffic control signal along the major street is less than 90 m (300 ft), unless the proposed traffic control signal will not restrict the progressive movement of traffic.

GUIDANCE:

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 series of signals, the traffic control signal should be coordinated.

4C.7 Warrant 6, Coordinated Signal System

SUPPORT:

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.

STANDARD:

The need for a traffic control signal shall 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.

GUIDANCE:

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.

4C.8 Warrant 7, Crash Experience

SUPPORT:

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.

STANDARD:

The need for a traffic control signal shall 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. Five or more reported crashes, of types susceptible to correction by a traffic control signal, have occurred within a 12-month period, each crash involving personal injury or property damage apparently exceeding the applicable requirements for a reportable crash; 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.2), or the vph in both of the 80 percent columns of Condition B in Table 4C-1 exists on the major-street and the higher-volume 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. These major-street and minor-street volumes shall be for the same 8 hours. On the minor street, the higher volume shall not be required to be on the same approach during each of the 8 hours.

OPTION:

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.

4C.9 Warrant 8, Roadway Network

SUPPORT:

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

STANDARD:

The need for a traffic control signal shall 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).

A major route as used in this signal warrant shall 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; or

B. It includes rural or suburban highways outside, entering, or traversing a city; or

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.

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

SUPPORT:

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 to the intersection of a grade crossing on an intersection approach controlled by a STOP or YIELD sign is the principal reason to consider installing a traffic control signal.

GUIDANCE:

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 intersection to make the approach across the track a non-stopping approach.

STANDARD:

The need for a traffic control signal shall 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 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) 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 1A.13.

GUIDANCE:

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 intersection at the track crossing location and Figure 4C-10 should be used if there are two or more lanes approaching the intersection at the track crossing location.

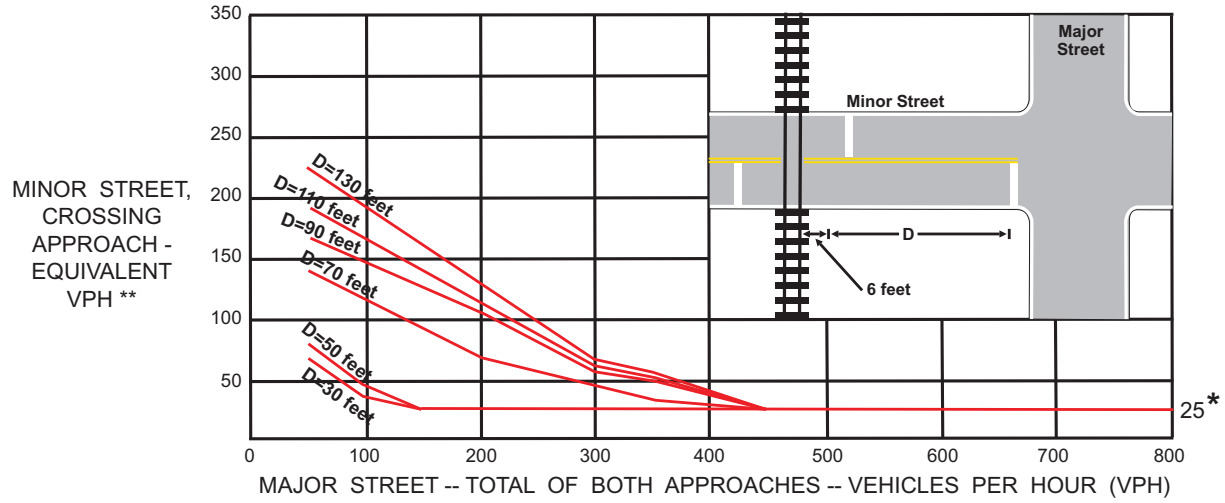
B. After determining the actual distance D, the curve for the distance D that is nearest to the actual distance D should be used. For example, if the actual distance D is 95 feet, the plotted point should be compared to the curve for D = 90 feet.

C. If the rail traffic arrival times are unknown, the highest traffic volume hour of the day should be used.

OPTION:

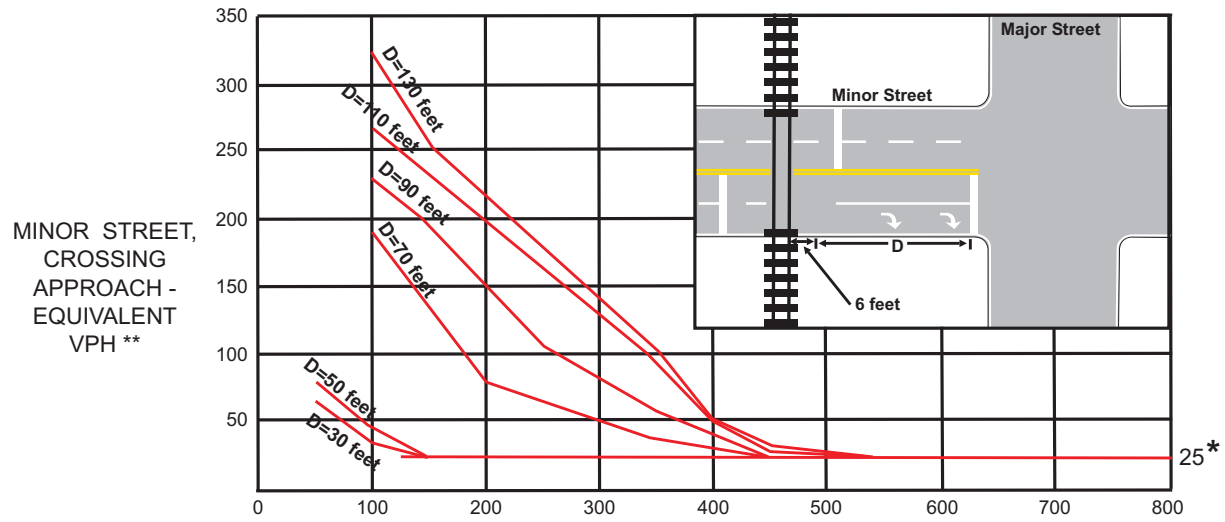
The minor-street approach volume may be multiplied by up to three adjustment factors as provided in Paragraphs 6 through 8.

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-2 for the appropriate number of occurrences of rail traffic per day.



* 25 vph applies as the lower threshold volume
** VPH after applying the adjustment factors in Tables 4C.2, 4C.3, and/or 4C-4, if applicable

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.2, 4C.3, and/or 4C-4, if applicable

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

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-3 for the appropriate percentage of high-occupancy buses.

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-4 for the appropriate distance and percentage of tractor-trailer trucks.

STANDARD:

If this warrant is met and a traffic control signal at the 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 4D.27, 8C.9, and 8C.10; and
C. The grade crossing shall have flashing-light signals (see Chapter 8C).

GUIDANCE:

If this warrant is met and a traffic control signal at the intersection is justified by an engineering study, the grade crossing should have automatic gates (see Chapter 8C).

Rail Traffic per Day	Adjustment factor
1	0.67
2	0.91
3 to 5	1.00
6 to 8	1.18
9 to 11	1.25
12 or more	1.33

Table 4C-2. Warrant 9 - Adjustment Factor for Daily Frequency of Rail Traffic

% of High-Occupancy Buses * on Minor-Street Approach	Adjustment factor
0%	1.00
2%	1.09
4%	1.19
6% or more	1.32

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

Table 4C-3. Warrant 9 - Adjustment Factor for Percentage of High-Occupancy Buses

% 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

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

HANDOUT

HANDOUT

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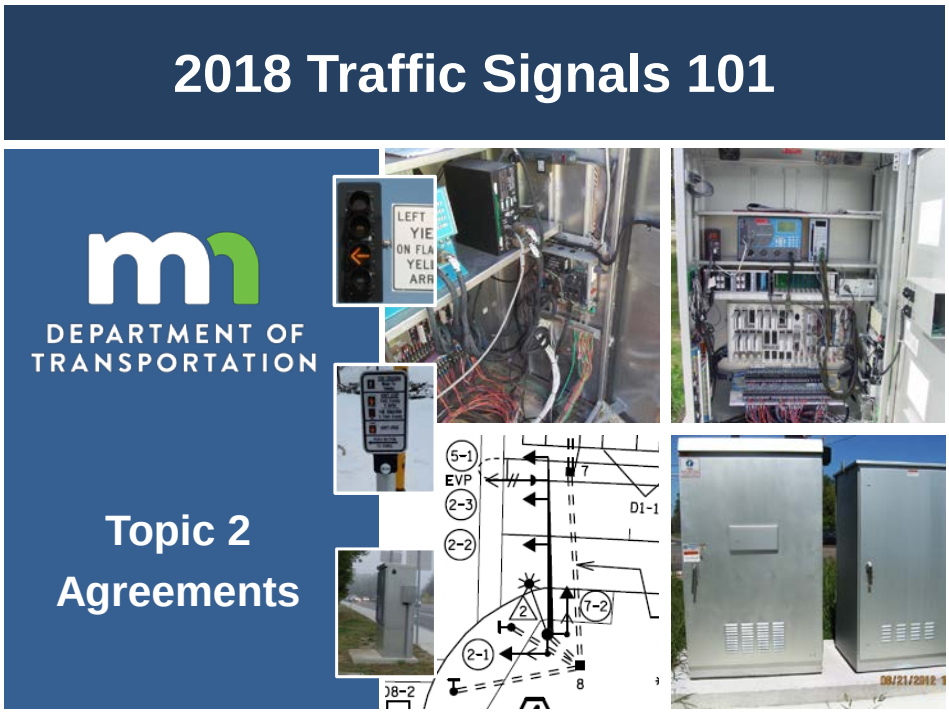
HANDOUT

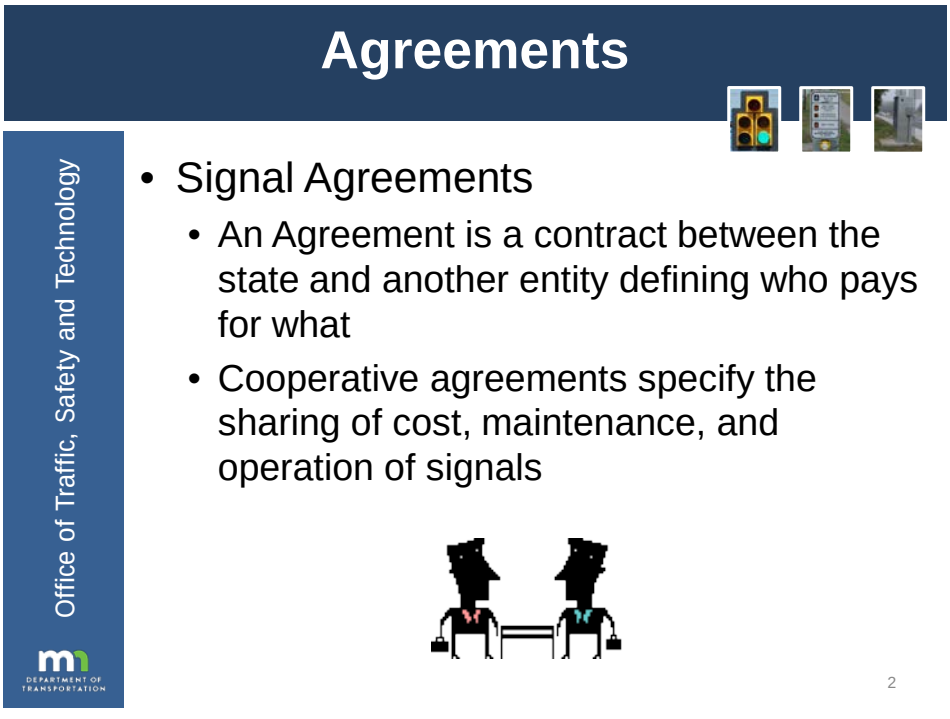
HANDOUT

TOPIC 2: AGREEMENTS



This topic will cover Agreements. This includes:

- Signal Agreements
- Cost Splits
- Type of Agreements written in the Traffic Office
- Agreements for State Let and City/County Let projects
- What agreements cover
- Items that may be covered in Agreements



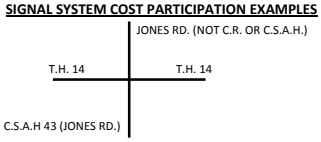
The State will not participate financially in a traffic signal that is not justified (see Chapter 1 regarding Intersection Control Evaluation).

Agreements

Office of Traffic, Safety, and Technology

- Cost Split
  - The cost of constructing and maintaining a traffic signal shall be shared by the State and other municipal agencies
    - Example:

SIGNAL SYSTEM COST PARTICIPATION EXAMPLES



① 4 LEGS TOTAL AT THE INTERSECTION
2 LEGS T.H. (STATE)
1 LEG C.S.A.H. (COUNTY)
1 LEG CITY ST. (CITY)

② THE MATHEMATICAL PROPORTIONS THEREFORE ARE:
50% STATE
25% COUNTY
25% CITY

③ APPLY THE COUNTY POLICY AND THE FEDERAL PARTICIPATION-THE FINAL PROPORTIONS ARE:
40% FEDERAL
10% STATE
25% COUNTY
25% CITY

④ WHEN APPLIED TO THE QUANTITIES CHART, THE PERCENTAGES BECOME:
0.4 FEDERAL
0.1 STATE
0.25 COUNTY
0.25 CITY

3

The construction cost is usually divided in the same ratio as the number of legs of the intersection under each jurisdiction. If a leg is split by a division boundary, that leg should be equally divided. A private entrance leg should be divided as a municipal leg.

Agreements

Office of Traffic, Safety and Technology

- Types of Agreements written in the Traffic Office:
  - Traffic Control Signal
  - Flashing Beacon
  - Emergency Vehicle Pre-emption (EVP)
  - Highway Lighting

4

The costs for the signal may include intersection roadway lights, intersection roadway signs, emergency vehicle preemption (EVP) as well as the cost of construction, engineering, inspection and maintenance.

Agreements

Office of Traffic, Safety and Technology

- Agreements are written for both State Let Projects and City/County Let Projects
- State Let Projects - Agreement Classifications
  - Receivable
  - Payable / Receivable
  - Maintenance
  - Reimbursable Maintenance
  - State Force Account

5

Agreements

Office of Traffic, Safety and Technology

- City/County Let Projects - Agreement Classifications
  - Payable / Receivable
  - Payable
  - Receivable
  - Maintenance
  - Reimbursable Maintenance
  - City Force Account
  - City / State Force Account
  - Agency

6

Traffic signal plans handled by Mn/DOT for other agencies, with or without the state aid process, are handled differently depending on whether the project has federal funding participation, and whether or not the intersection involved is on or off the trunk highway system.

If a signal at a trunk highway intersection is being built or revised by any other agency, the District/Division Traffic Engineer shall approve the final plans before bids are opened on the project. The Traffic Engineer shall approve the plans whether or not there is any federal funding participation.

If a proposed signal is not at a trunk highway location, and the job involves federal funding participation, the Traffic Engineer will indicate concurrence with the design by means of a memorandum to the State Aid office.

If a proposed signal is not at a trunk highway location, and the job does not have federal funding participation, the Traffic Engineer may indicate approval by means of a memo to the State Aid Office; however, the district/division may recommend approval of such a project if the plans have been certified by both a master electrician and licensed engineer.

Agreements

Office of Traffic, Safety and Technology

- What Agreements Cover
  - Costs (Construction costs and appropriate shares)
  - Maintenance
  - Operation (Timing)
  - Electrical Energy (Power)

7

Agreement terms (cost participation, power supply, design responsibilities, operation responsibilities and major/minor maintenance responsibilities) should be defined as early as possible within any project - regardless of whether the project is going to be administered by the Department or a local agency. Agreement terms are a byproduct of appropriate and timely local agency and Department contact regarding any project.

Refer to the Cooperative Purchasing Venture at the following web site: **http://www.mmd.admin.state.mn.us/cpv2.htm**

Agreements

Office of Traffic, Safety and Technology

- Items that may be covered in the Agreements
  - Signals
  - Street Lights
  - Advanced Warning Flashers
  - Signal Ahead Flashers
  - Interconnect
  - Emergency Vehicle Pre-emption
  - Type “D” Signs

8

The cost is also split by leg for interconnect (communications devices for adjacent intersections in a signal system).

Agreements

Office of Traffic, Safety and Technology

- Items that may be covered (continued)
  - Internally Lit Signs
  - Cross-walk markings
  - Intersection Improvements
  - Beacons
  - Lighting Systems
  - Lighting Units
  - Preliminary Engineering

9

Agreements

Office of Traffic, Safety and Technology

- Items that may be covered (continued)
  - Engineering & Inspection
  - State Furnished Materials (Cabinet and Controller)
  - City / County Furnished Materials

10

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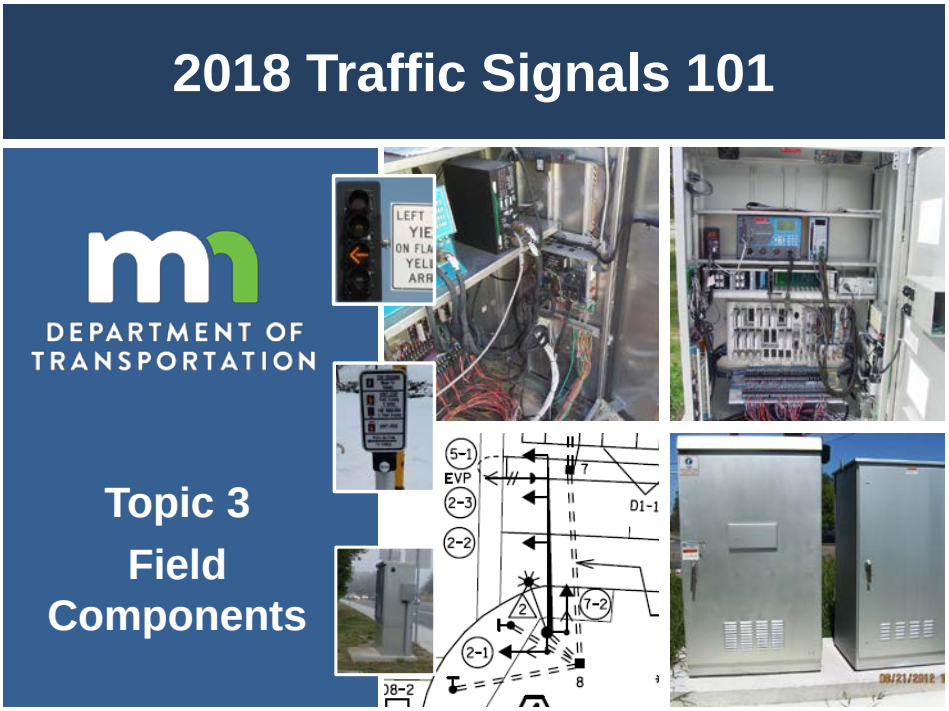
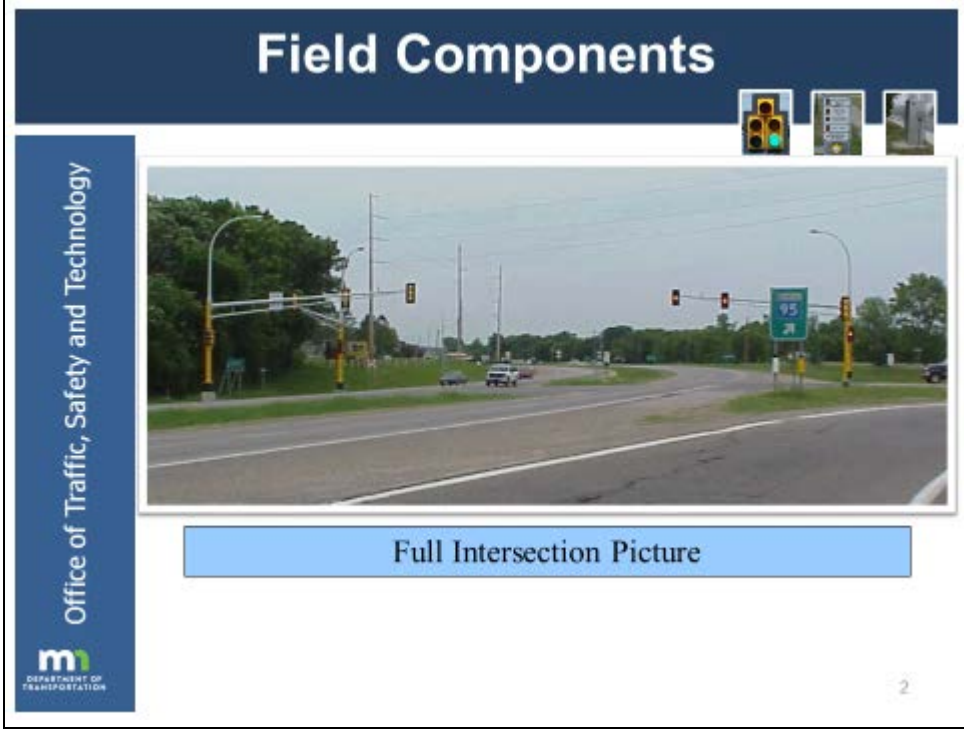
TOPIC 3: FIELD COMPONENTS



In this topic you will be introduced to some common field components used with traffic signals.

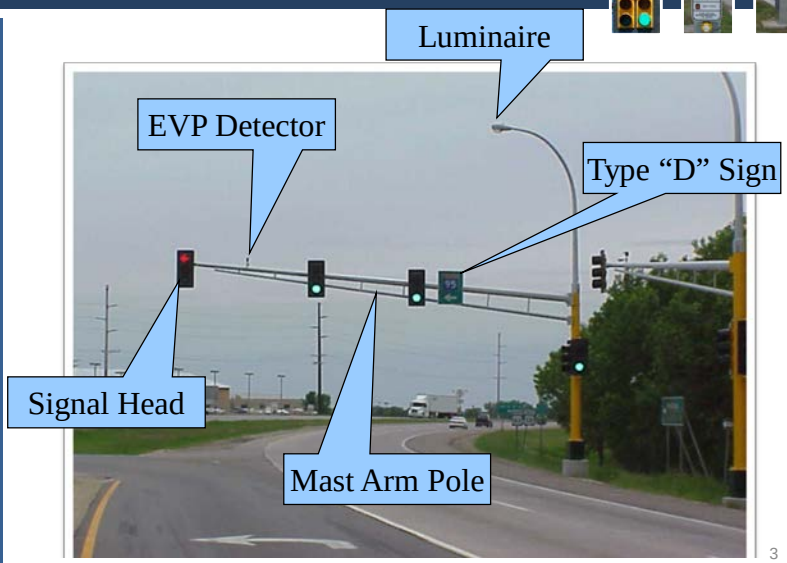
At the end of this topic you will find a copy of the pertinent Standard Plates. These are current at the time of publication of this manual.



This is a picture of a signalized intersection.

Field Components

Office of Traffic, Safety, and Technology



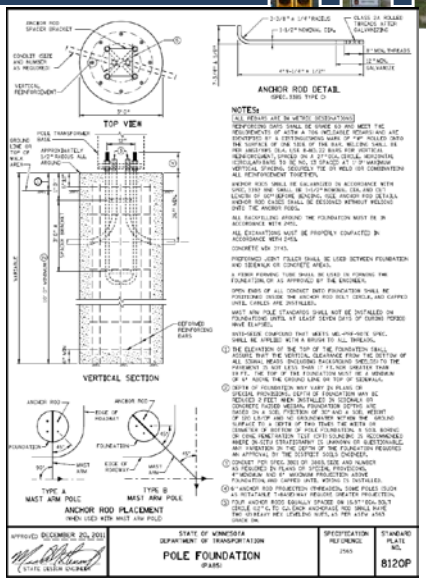
3

This picture identifies a mast arm pole and some of the common components found on it. This includes emergency vehicle preemption (EVP detector), traffic signal heads (protected and permitted), a luminaire for lighting the roadway and a Type "D" guide sign.

Field Components

Office of Traffic, Safety, and Technology

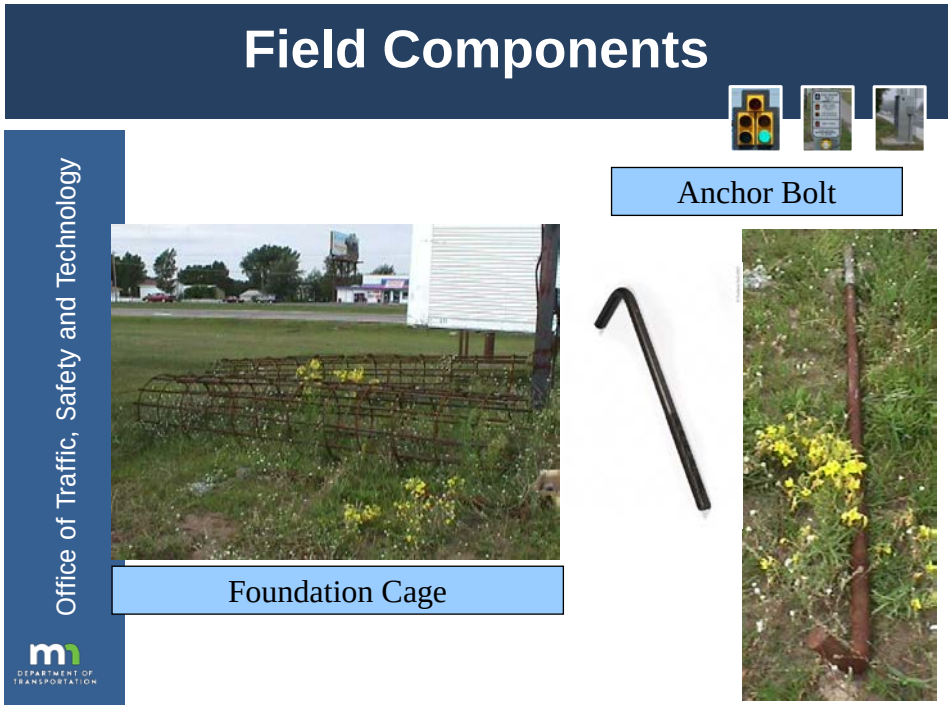
- Foundation Standard Plate



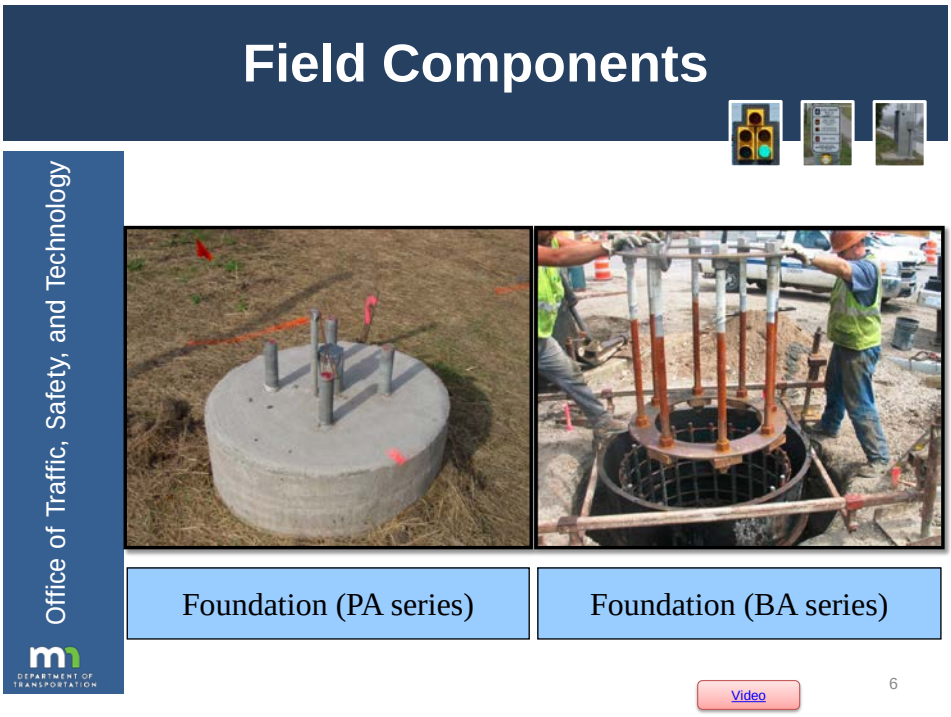
4

This is Standard Plate No. 8120, Pole Foundation for a type PA85. Standard Plate No. 8126 is for foundation PA90 and PA100 (longer mast arms) and 8133 is for Type BA. See page 3-5 for information on mast arm lengths).

Refer to the Standard Plates for the most current version.



The pictures in the slide show a steel foundation cage (reinforcing bars) and an anchor bolt. See Standard Plate 8120N for details.

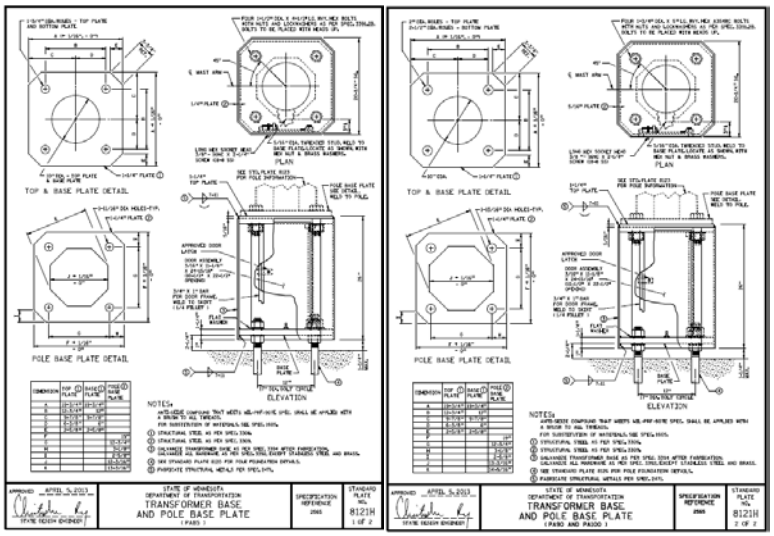


This picture shows the foundation at grade level (PA series) and under construction (BA series). Notice the anchor rods where the signal transformer base attaches.

Field Components

Office of Traffic, Safety and Technology

- Transformer Standard Plate



This is Standard Plate No. 8121 (page 1 and 2), Transformer Base and Pole Base Plate.

Field Components

Office of Traffic, Safety, and Technology

Pole Base
and Transformer

The pictures in the slide show a pole base and transformer. See Standard Plate 8121 for details.

Field Components

Office of Traffic, Safety, and Technology

Transformer Access Panels

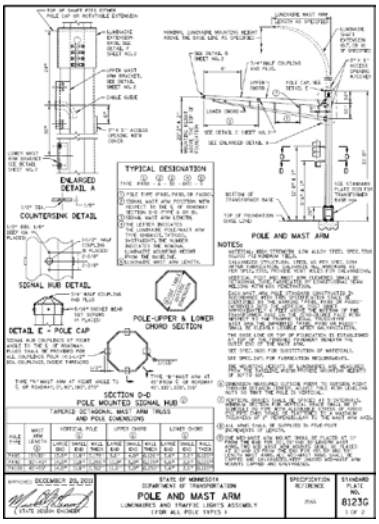
9

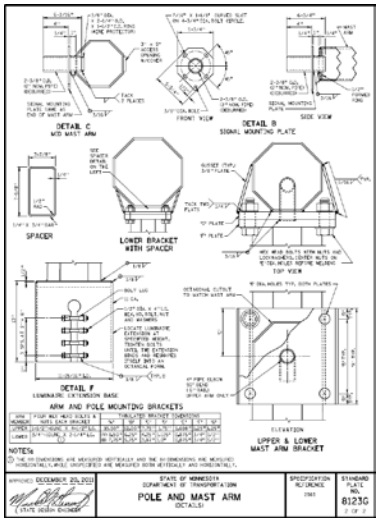
This picture shows a transformer base access panel. The picture on the left is on a pedestal pole and the picture on the right is for a mast arm (with access panel open). See Standard Plate 8121 for details.

Field Components

Office of Traffic, Safety and Technology

- Pole and Mast Arm Standard Plate





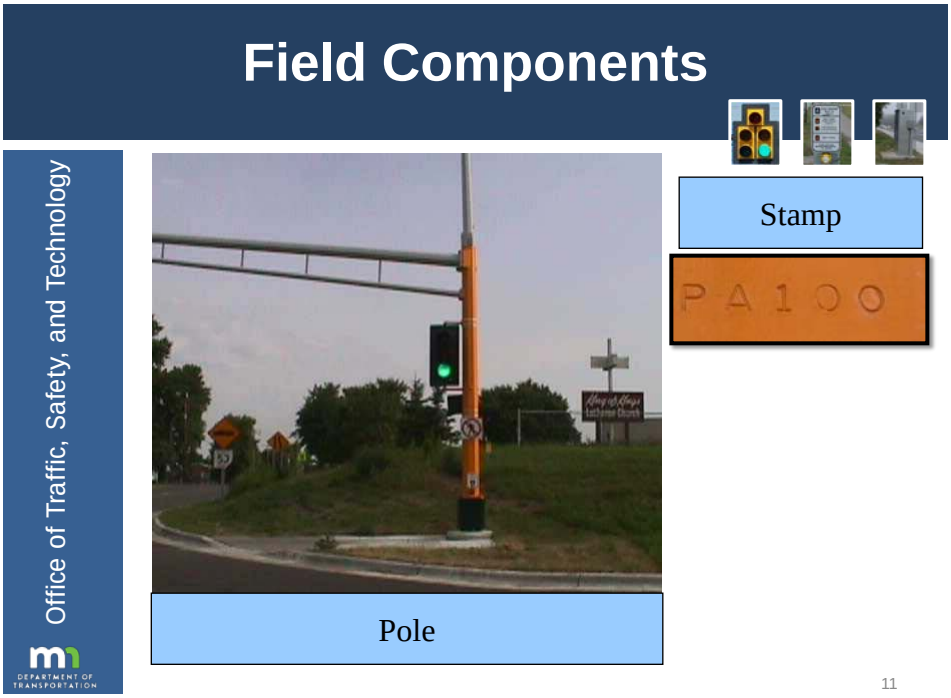
This is Standard Plate No. 8123 (page 1 and 2), Pole and Mast Arm.

Notice that there are 3 types that are used:

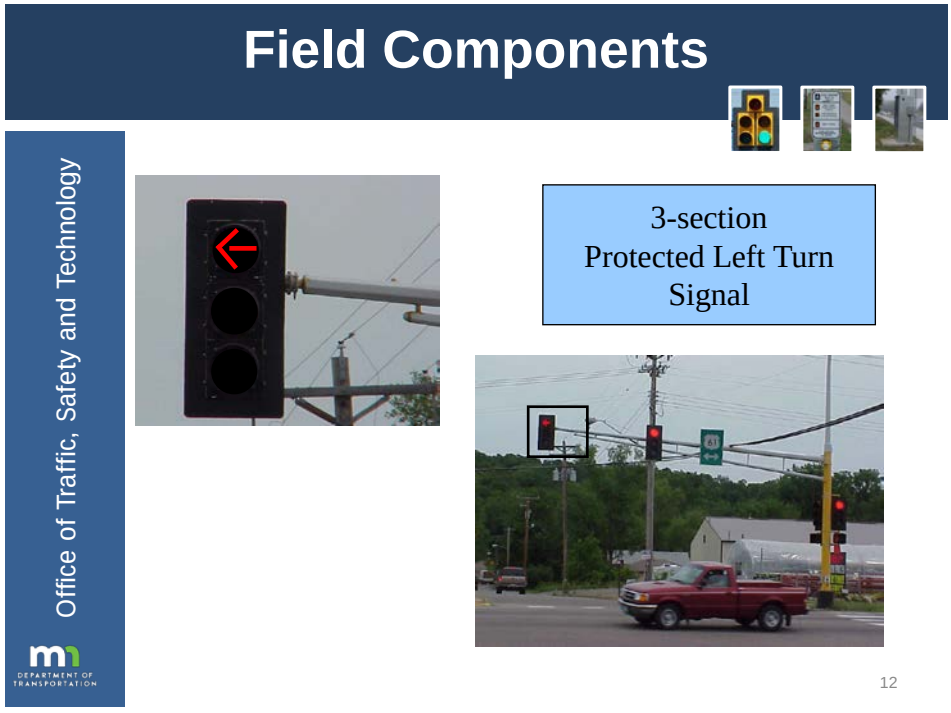
PA85 (15' - 30')
PA90 (30' - 40')
PA100 (40-55')

The length of the arm is specified on the signal layout plan sheets (see topic 4).

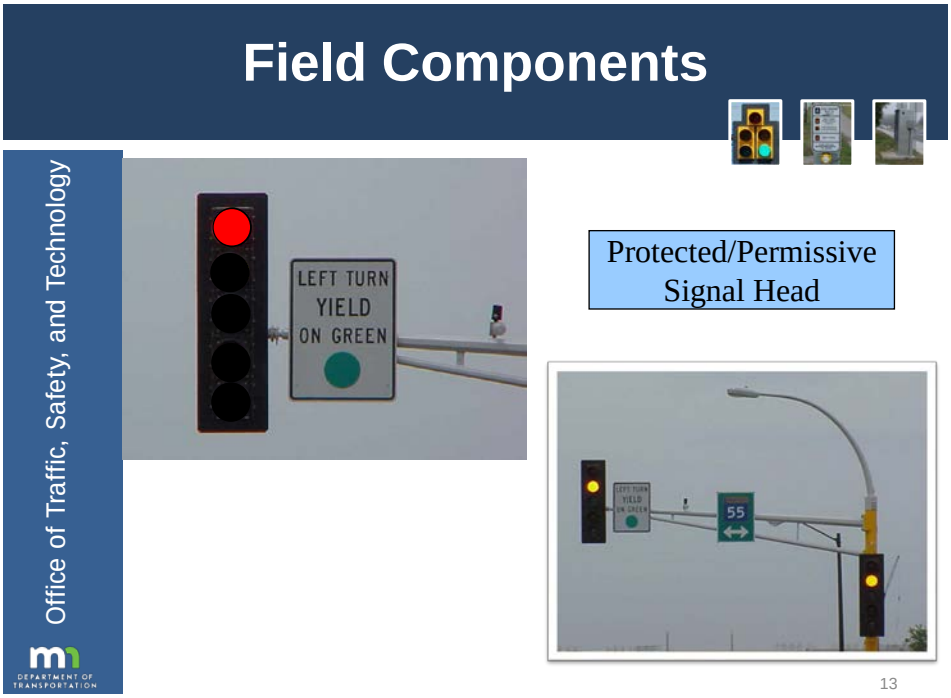
Standard Plate No. 8133 Pole and Mast Arms – Type BA.



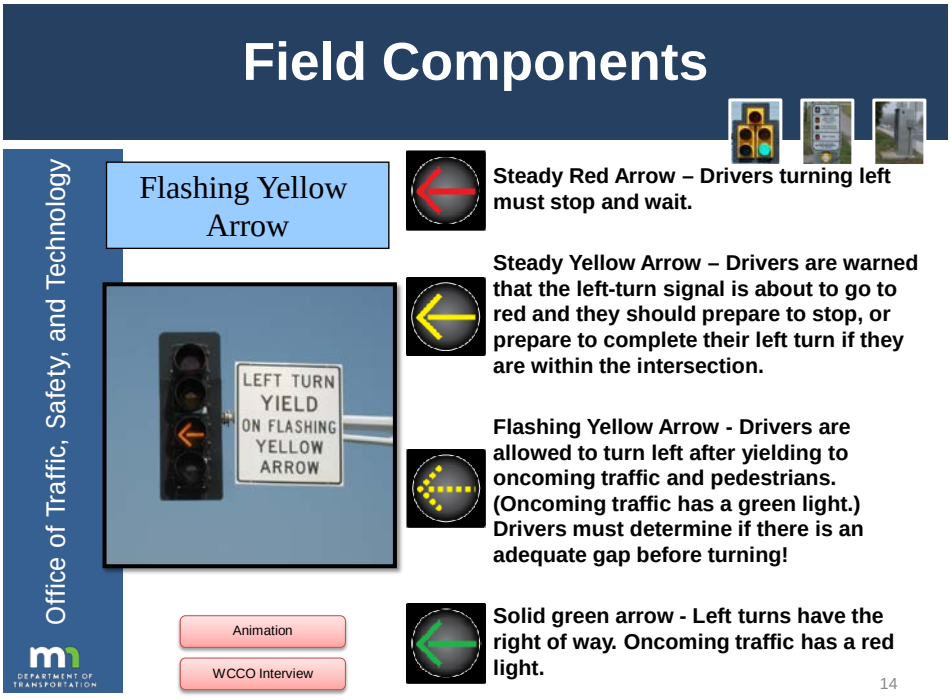
This picture shows the vertical pole (yellow post shown in the picture on the left) and a stamp indicating that this is a Pole Type PA100 (right). See Standard Plate 8123 for details.



This shows a picture of a 3-section protected left turn signal. In a protected left, all three indications are arrow type. Vehicles are only allowed to move during the green indication (no permissive left turn movement is allowed).



These pictures show a protected/permissive left turn signal. Left turn vehicles are allowed to operate as a protected movement during the green arrow and as a permissive movement (yield to oncoming traffic) during the green ball. Notice the supplemental 'Left Turn Yield on Green' sign.



The Minnesota Department of Transportation and several other jurisdictions are among some of the first jurisdictions in the United States to implement the flashing yellow arrow left-turn signal light at intersections where in the past circular green signal lights were used. Both types of signal lights direct motorists to turn left after yielding to oncoming traffic.

Refer to the Mn/DOT OTSO link for additional details on flashing yellow arrows.
www.dot.state.mn.us/trafficeng/signals/flashingyellowarrow.html

Field Components

Office of Traffic, Safety and Technology

Mast Arm Pole

15

This picture shows the horizontal mast arm pole. See Standard Plate 8123 for details. Mast arm poles are supplied in 5' increments from 15' to 55'.

MnDOT recently created footing designs for longer mast arms (Type BA). The new designs allow mast arms from 60’ to 80’. The longer mast arms have been implemented at a several locations.

The foundation can be a drilled shaft or spread footing design. The preferred method is the drilled shaft.

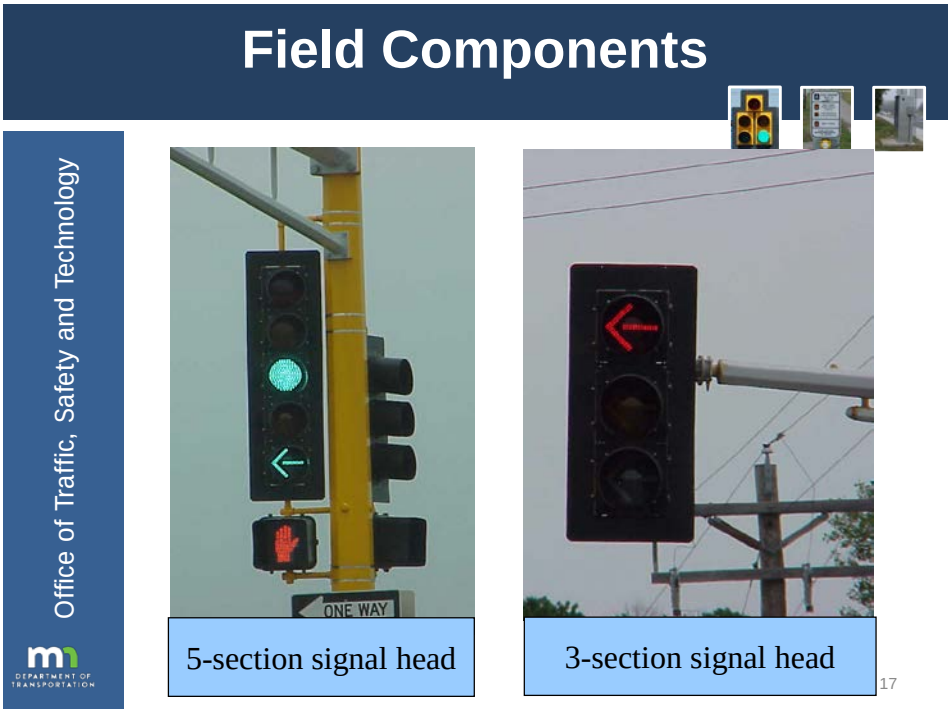
Field Components

Office of Traffic, Safety, and Technology

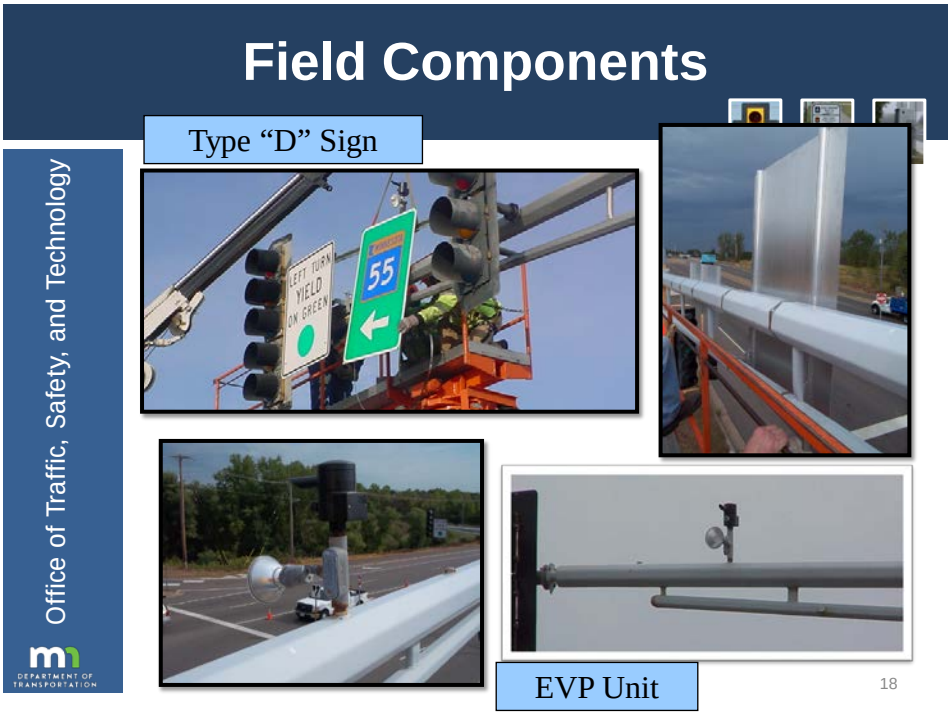
Arm Spacing

16

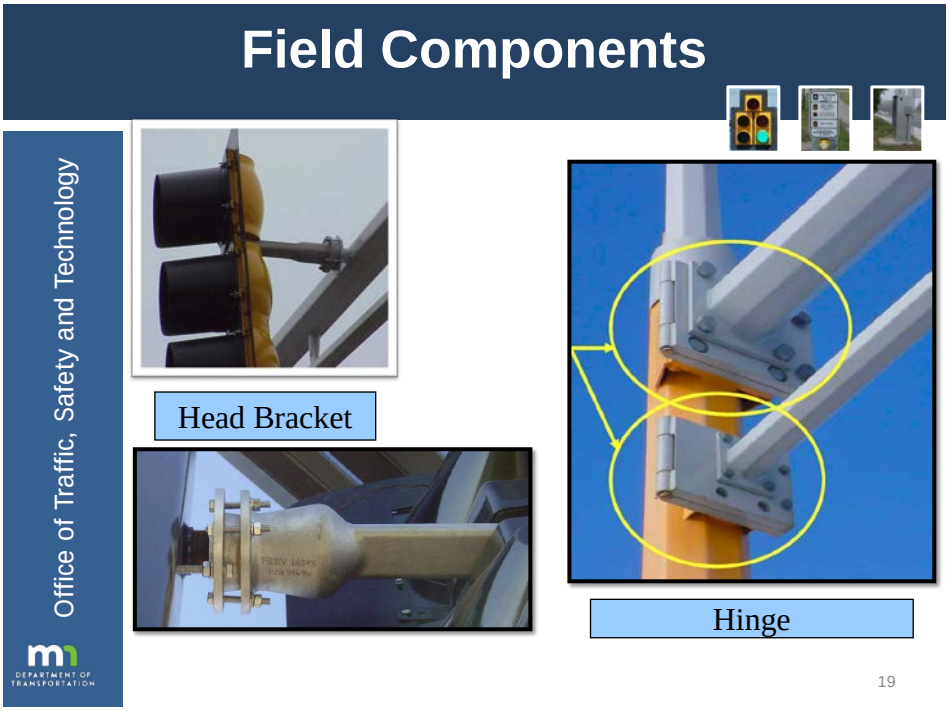
This picture shows the vertical braces on a mast arm pole. The braces are spaced at 5' intervals. See Standard Plate 8123 for details.



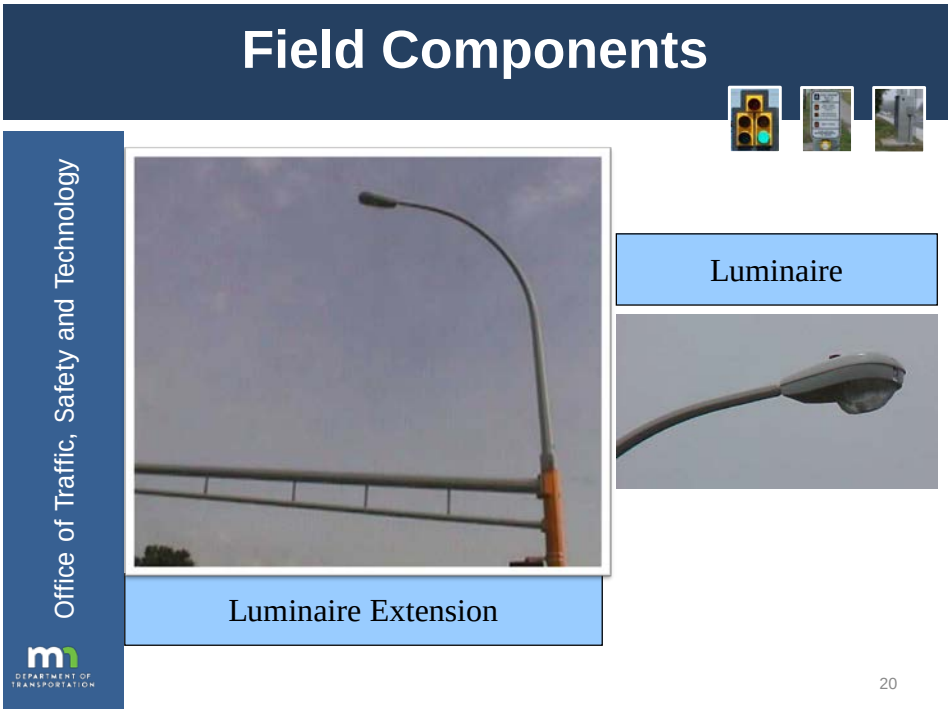
The picture on the left shows a typical 5-section signal head on a vertical pole and the picture on the right is a typical 3-section head mounted on the end of a mast arm.



The pictures on the top show a typical Type "D" guide sign (front and back). The pictures on the bottom show a close up view of an Emergency Vehicle Preemption (EVP) detector and confirmatory light. See topic 12 for more information on EVP.



The pictures on the left show a typical signal head-mounting bracket. The picture on the right shows a hinge where the mast arm is mounted to the pole. The hinge allows the mast arm to be rotated if it is on a house-moving route.



The picture on the left shows the luminaire shaft extension. The picture on the right is the luminaire head.

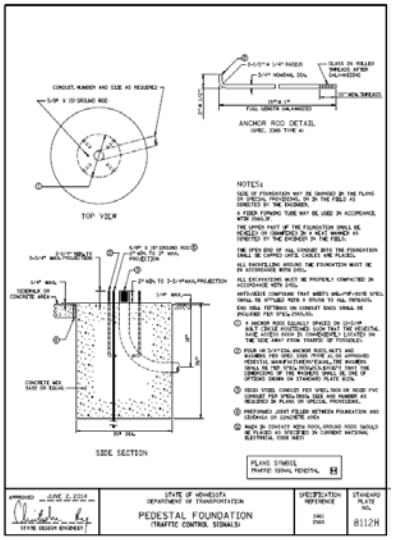
Generally, there are at least two luminaires at an intersection.

The luminaire has a photoelectric cell.

Field Components

Office of Traffic, Safety, and Technology

- Ped Foundation Standard Plate



21

This is Standard Plate No. 8112, Pedestal Foundation. Refer to the Standard Plates for the most current version.

Field Components

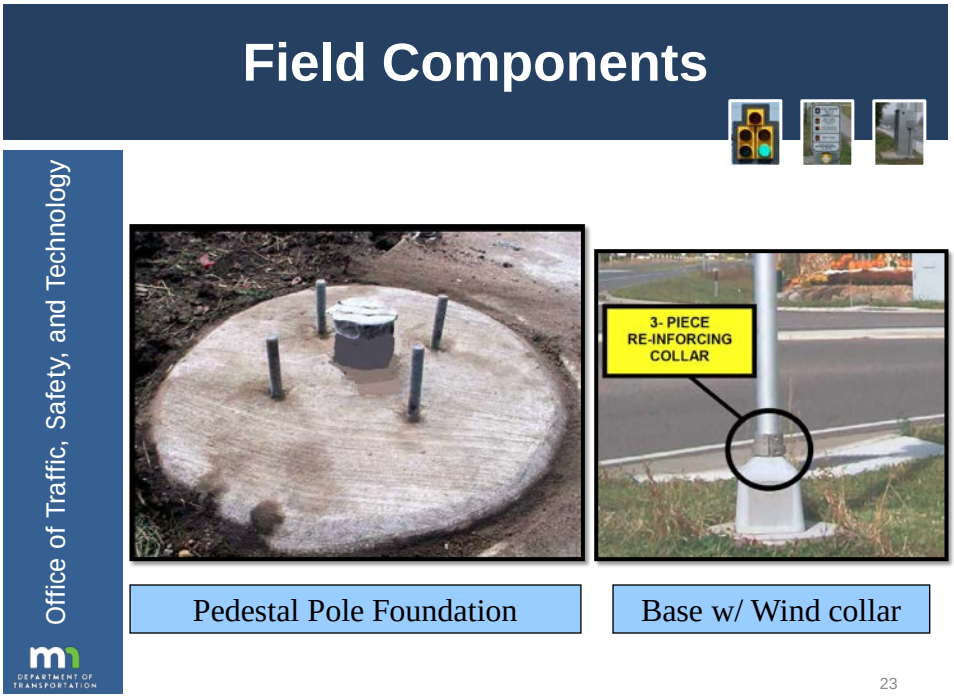
Office of Traffic, Safety and Technology

Pedestal Pole

Pedestal Base

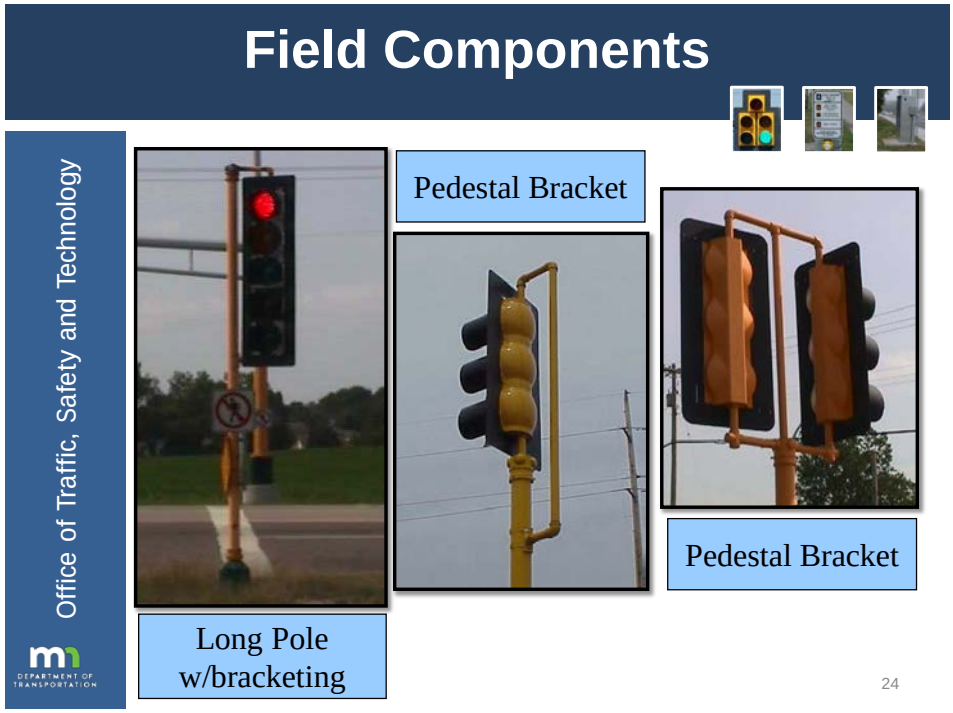
22

The picture on the left shows 3-section left turn signals mounted on top of a pedestal pole. The picture on the right is a close up of the pedestal pole base and foundation.



The picture on the left is the concrete pedestal foundation and the anchor rods. The picture on the right shows the base and wind collar.

See Standard Plate 8112 for details on the pedestal foundation.

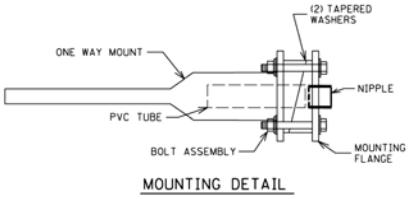


The pictures in the slide show some typical mounting assemblies for traffic signal heads on a pedestal pole.

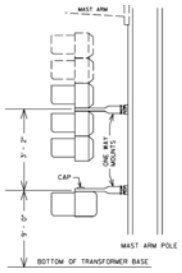
Field Components

Office of Traffic, Safety, and Technology

One Way Signal & Pedestrian Indication Mount



MOUNTING DETAIL



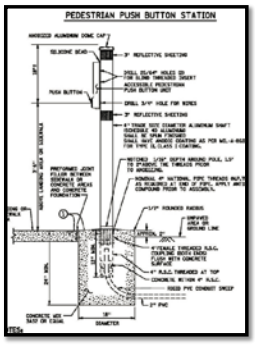
25

One way Signal and Pedestrian indication bracket picture and mounting detail.

Field Components

Office of Traffic, Safety and Technology

Pedestrian Push Button Station



Push Button Station Detail (Signal Plan Detail)

Push Button Sign

26

The picture on the left shows a pedestrian push button station. The picture in the middle shows the push button detail from the plan set. The picture on the right shows a close-up of a pedestrian push button and push button sign.

Field Components

Office of Traffic, Safety and Technology

- Pedestrian Hybrid Beacons
  - Often referred to as a HAWK Signal

27

Additional Information can be found at:
www.dot.state.mn.us/d3/hottopics/hawk.html

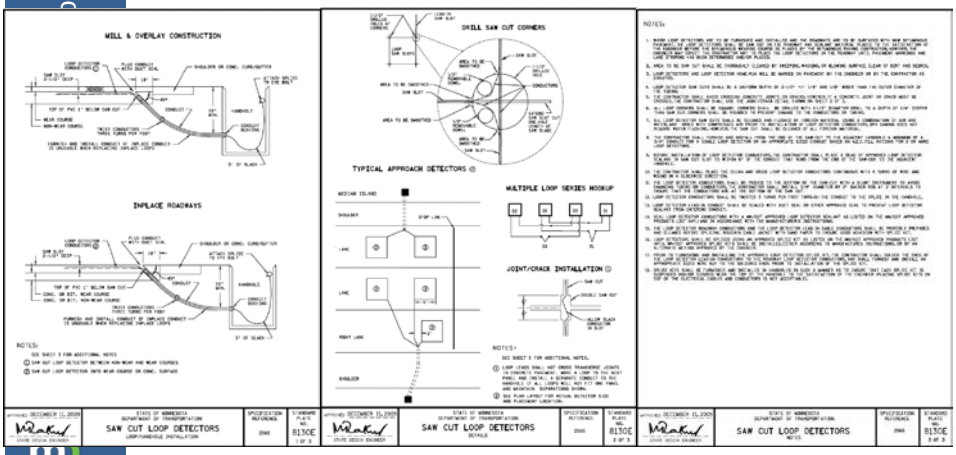
From the 2009 Edition of the Federal Manual on Uniform Traffic Control Devices, "A pedestrian hybrid beacon is a special type of hybrid beacon used to warn and control traffic at an unsignalized location to assist pedestrians in crossing a street or highway at a marked crosswalk."

This type of signal is commonly referred to as a HAWK signal. "HAWK" stands for **H**igh-intensity **A**ctivated cross-**W**al**K**.

The City of St. Cloud and Mn/DOT have installed the first HAWK system in the mid-west on Highway 23 at 12th Avenue adjacent to the new library and Tech High School.

Field Components

- Saw Cut Detail

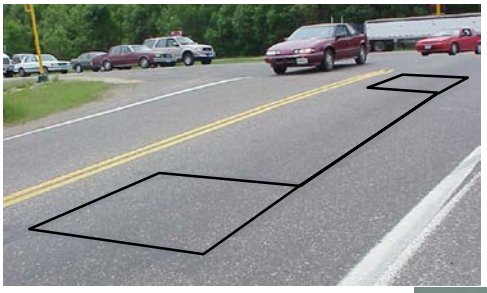


28

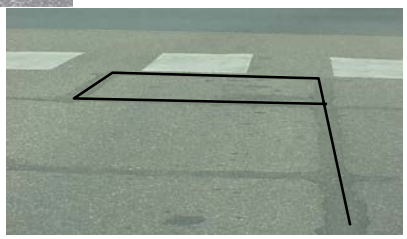
This is Standard Plate No. 8130, Saw Cut Loop Detectors.

Field Components

Office of Traffic, Safety and Technology



Saw-Cut
Loop Detector



29

These pictures show loop detectors that are placed in the roadway by saw-cut. The detectors have been outlined for these pictures only.

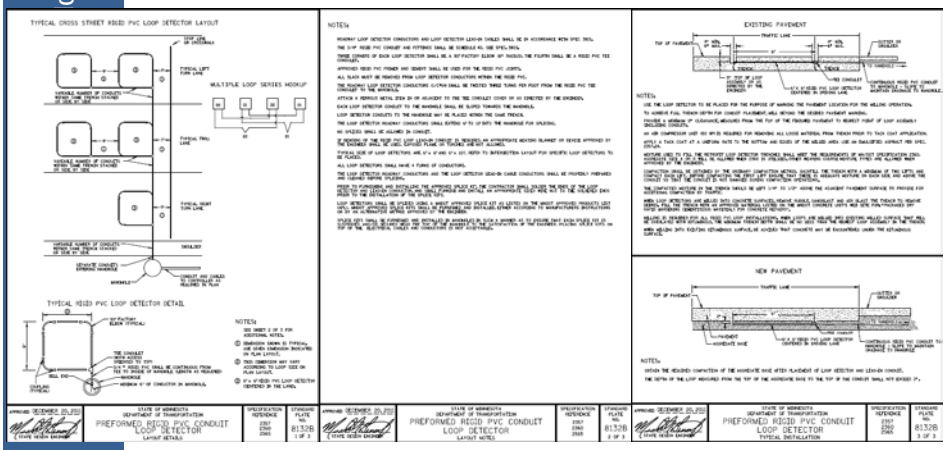
Conductor wire is placed in the saw cuts and covered with epoxy filler. The loops are used to detect vehicles.

See Standard Plate 8130 for details.

Field Components

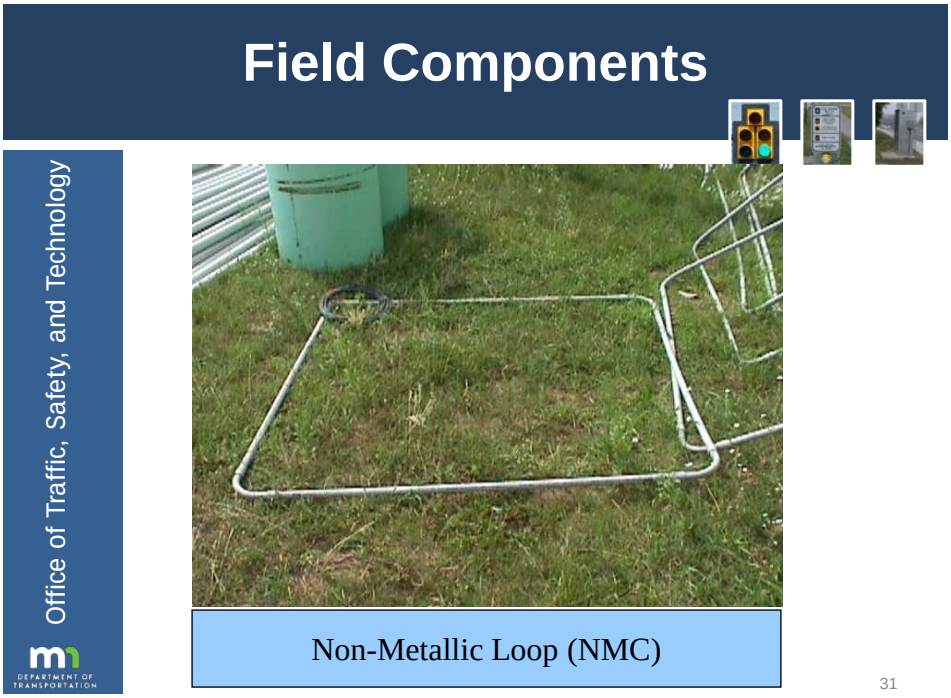
ogy

- Non-Metallic Loop Detail

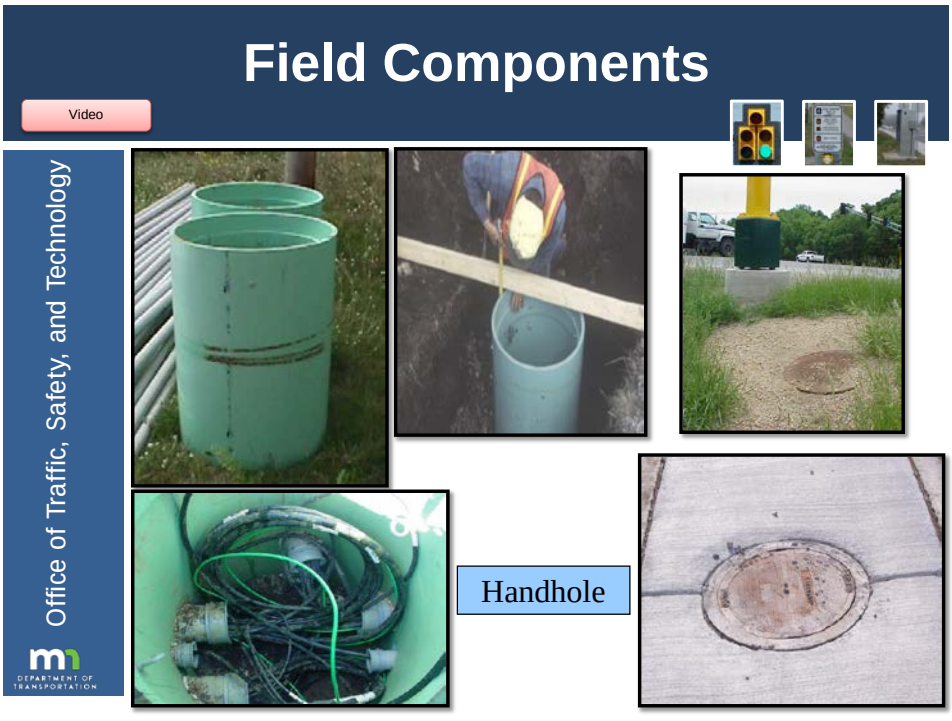


30

This is Standard Plate No. 8132, Preformed Rigid PVC Conduit Loop Detector.



This is a picture of a NMC loop conduit. Conductor wire is placed in the conduit and the loop assembly is placed in or under the roadway. The NMC loop is used to detect vehicles.



The picture on the left shows the handhole barrel prior to installation. The upper middle shows the handhold during construction. The lower left is a top view with wires. The pictures on the right show typical handhole installations.

A handhole is used as an access to conduit and wire. The lid can be removed.

See the Standard Specifications, Special Provisions and Approved Products List for details.

Field Components

Office of Traffic, Safety, and Technology

Crosswalk

Pedestrian Ramp

33

The picture on the left shows a typical crosswalk marking. This indicates where pedestrians cross the roadway.

The picture on the right shows a typical pedestrian curb ramp installation.

Field Components

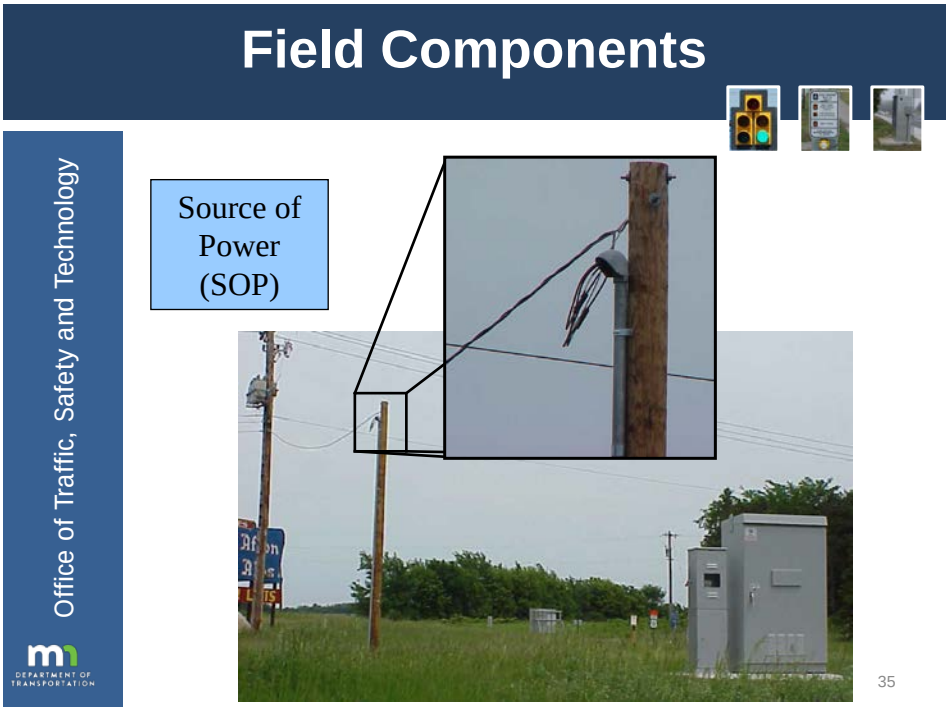
Office of Traffic, Safety and Technology

Signal Cabinet and Pad

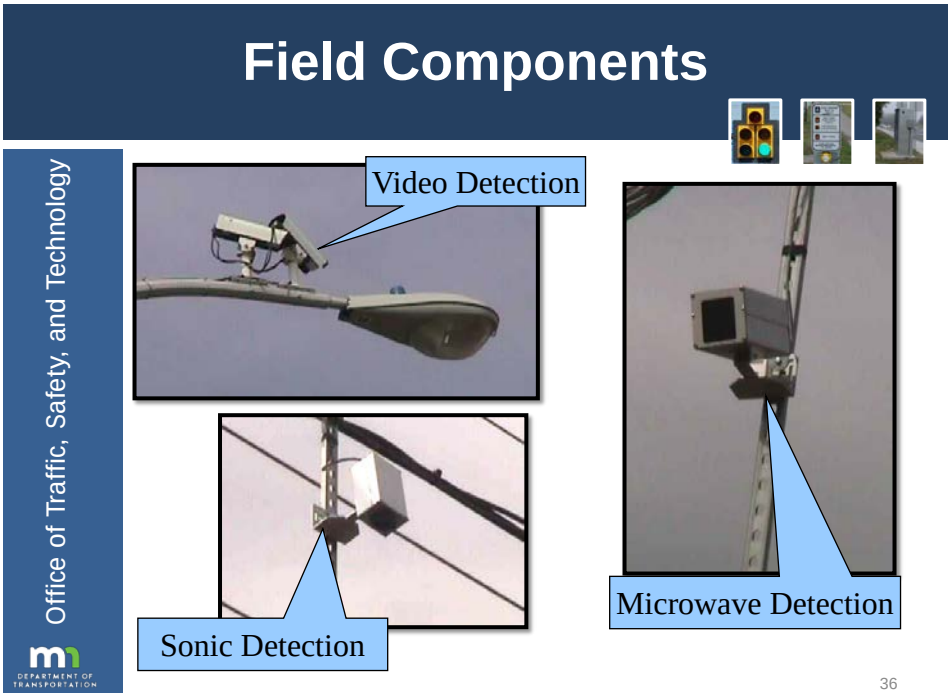
Service Cabinet

34

These pictures show a typical traffic signal cabinet and service cabinet installation. See topic 5 for further details.



These pictures show a typical source of power (SOP).



When loop detectors are not present, other forms of vehicle detection may be installed. These pictures show some other forms of detection. Typically, these detectors are installed overhead.

Field Components

Office of Traffic, Safety, and Technology

- Enforcement Lights

37

The bright blue lights, placed at 90-degree angles on the poles, activate when the signal turns red. It is visible to officers parked nearby but not to approaching traffic. Law enforcement uses the light to spot red-light runners.

Field Components

Office of Traffic, Safety, and Technology

Signal Ahead Sign

38

This is a picture of a signal ahead sign. This is installed prior to traffic signals to warn the motorist that a signal is ahead.

Field Components

Office of Traffic, Safety, and Technology

Advance Warning Flasher (AWF)

39

These pictures show a typical Advance Warning Flasher installation. It differs from the signal ahead sign since it has flashers. See topic 10 for further details.

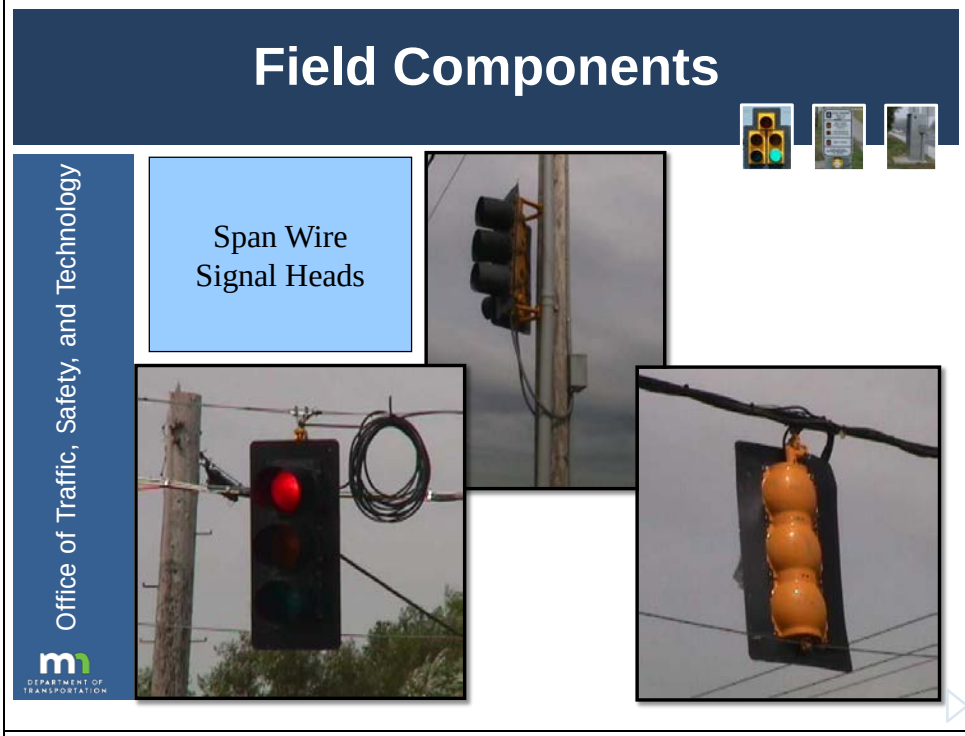
Field Components

Office of Traffic, Safety, and Technology

Span Wire Signal

40

This is a picture of a typical span wire signal. Generally, these are temporary installation, but some may be long term. Generally the traffic signal wires are installed overhead instead of underground.

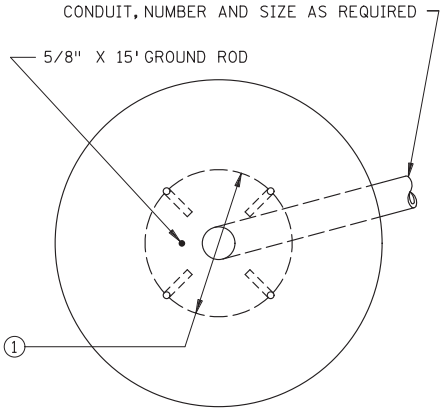


Close-up pictures of span wire signal heads.

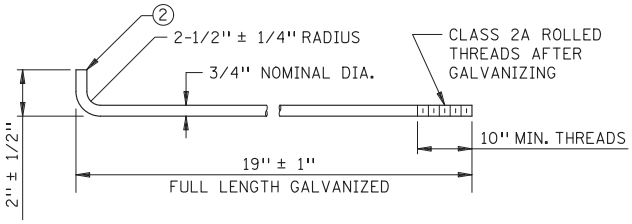
The products on this site have been pre-approved for use on MnDOT projects. Click on the Signals link for Traffic Control Signal Products.

http://www.dot.state.mn.us/products/

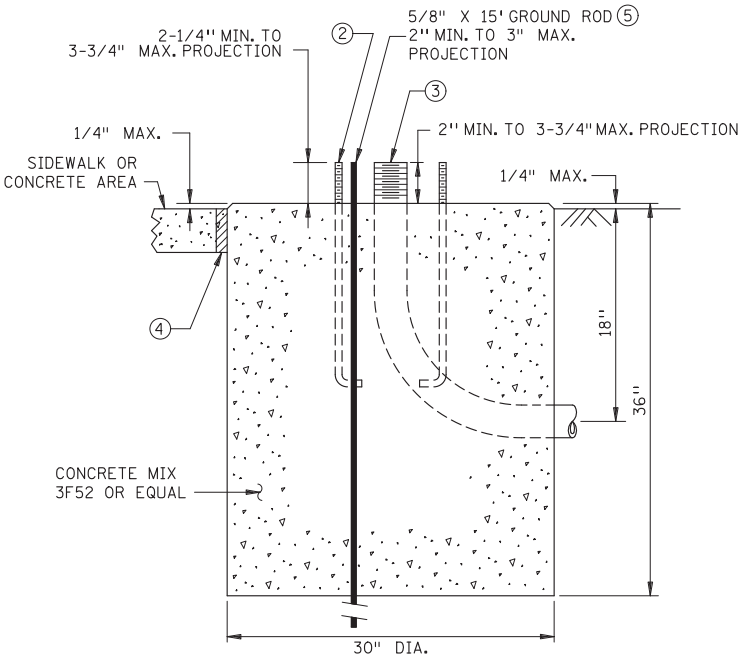
Handout
Selected Mn/DOT Standard Plates
For the latest version of the Standard Plates, please visit:
http://standardplates.dot.state.mn.us/StdPlate.aspx



TOP VIEW



ANCHOR ROD DETAIL
(SPEC. 3385 TYPE A)



SIDE SECTION

NOTES:

SIZE OF FOUNDATION MAY BE CHANGED IN THE PLANS OR SPECIAL PROVISIONS, OR IN THE FIELD AS DIRECTED BY THE ENGINEER.

A FIBER FORMING TUBE MAY BE USED IN ACCORDANCE WTIH 2565.3F.

THE UPPER PART OF THE FOUNDATION SHALL BE BEVELED OR CHAMFERED IN A NEAT MANNER AS DIRECTED BY THE ENGINEER IN THE FIELD.

THE OPEN END OF ALL CONDUIT INTO THE FOUNDATION SHALL BE CAPPED UNTIL CABLES ARE PLACED.

ALL BACKFILLING AROUND THE FOUNDATION MUST BE IN ACCORDANCE WITH 2451.

ALL EXCAVATIONS MUST BE PROPERLY COMPACTED IN ACCORDANCE WITH 2451.

ANTI-SEIZE COMPOUND THAT MEETS MIL-PRF-907E SPEC. SHALL BE APPLIED WITH A BRUSH TO ALL THREADS.

END BELL FITTINGS ON CONDUIT ENDS SHALL BE INCLUDED PER SPEC. 2565.3D.

(1) 4 ANCHOR RODS EQUALLY SPACED ON 12-3/4" BOLT CIRCLE POSITIONED SUCH THAT THE PEDESTAL BASE ACCESS DOOR IS CONVENIENTLY LOCATED ON THE SIDE AWAY FROM TRAFFIC (IF POSSIBLE).

(2) FOUR (4) 3/4" DIA. ANCHOR RODS, NUTS AND WASHERS PER SPEC. 3385 (TYPE A), OR APPROVED PEDESTAL MANUFACTURERS' EQUAL. THE WASHERS SHALL BE PER SPEC. 3832.2C3, EXCEPT THAT THE DIMENSIONS OF THE WASHERS SHALL BE ONE OF OPTIONS SHOWN ON STANDARD PLATE 8129.

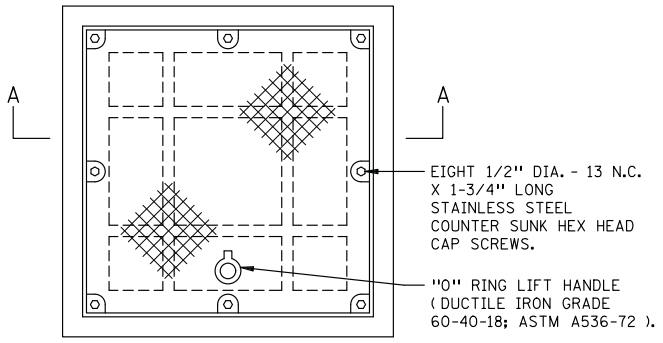
(3) RIGID STEEL CONDUIT PER SPEC. 3801 OR RIGID PVC CONDUIT PER SPEC. 3803. SIZE AND NUMBER AS REQUIRED IN PLANS OR SPECIAL PROVISIONS.

(4) PREFORMED JOINT FILLER BETWEEN FOUNDATION AND SIDEWALK OR CONCRETE AREA

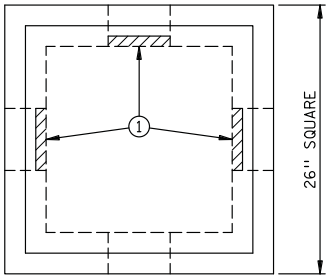
(5) WHEN IN CONTACT WITH ROCK, GROUND RODS SHOULD BE PLACED AS SPECIFIED IN CURRENT NATIONAL ELECTRICAL CODE (NEC)

PLANS SYMBOL
TRAFFIC SIGNAL PEDESTAL

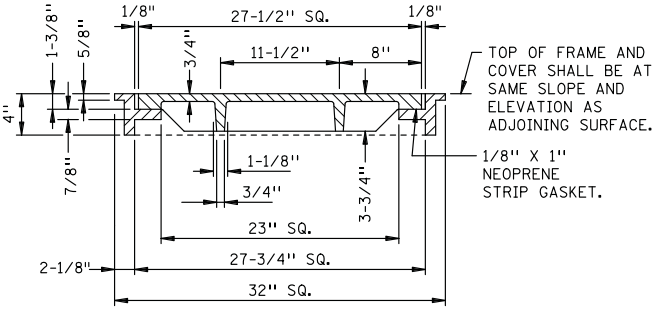
APPROVED JULY 15, 2015 STATE DESIGN ENGINEER	STATE OF MINNESOTA DEPARTMENT OF TRANSPORTATION PEDESTAL FOUNDATION (TRAFFIC CONTROL SIGNALS)	SPECIFICATION REFERENCE 2461 2565	STANDARD PLATE NO. 8112I



PLAN



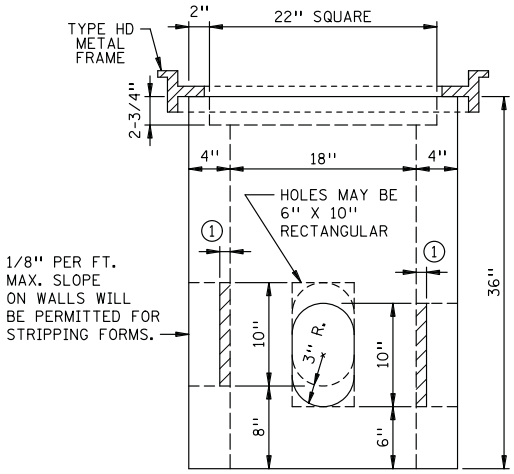
TOP VIEW



SECTION A-A

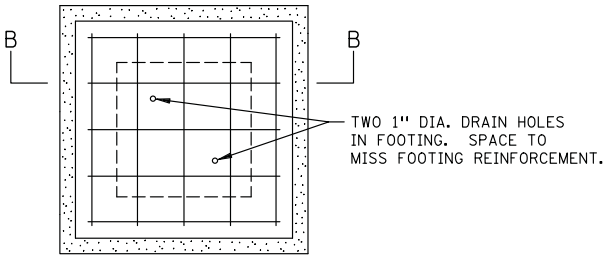
TYPE HD - METAL FRAME AND COVER

SPEC. 3321

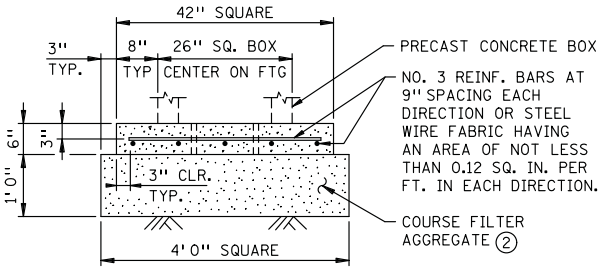


ELEVATION

PRECAST CONCRETE BOX



PLAN



SECTION B-B

"HD" CONCRETE FOOTING

NOTES:

TYPE HD METAL FRAMES AND COVERS SHALL BE COATED WITH MANUFACTURER'S SHOP COAT OF ASPHALT PAINT.

AFTER HANDHOLE AND CONDUIT INSTALLATION, ALL INSIDE HANDHOLE SIDE WALLS SHALL BE MADE WATER TIGHT BY PATCHING WITH CONCRETE TO THE SATISFACTION OF THE ENGINEER.

FOOTING MAY BE PRECAST OR CAST-IN-PLACE.

METAL FRAME AND COVER SHALL BE INDEPENDENTLY GROUNDED IN ACCORDANCE WITH THE NATIONAL ELECTRICAL CODE (NEC) 314.30.

EXCAVATIONS AND BACKFILLING SHALL BE IN ACCORDANCE WITH 2451.

F&I HANDHOLE IN ACCORDANCE WITH 2565.3E.

F&I CONDUITS IN ACCORDANCE WITH 2565.3D.

F&I END BELL FITTINGS ON RIGID PVC CONDUIT IN ACCORDANCE WITH 2565.3D.

EMBOSS "MnDOT SIGNALS" ON THE COVER FOR TRAFFIC SIGNAL CONTROL PROJECTS.

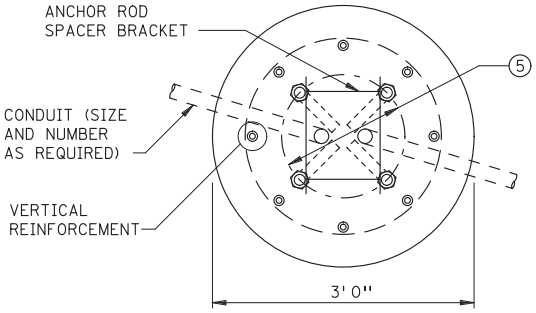
EMBOSS "MnDOT LIGHTING" ON THE COVER FOR ROADWAY LIGHTING PROJECTS.

EMBOSS "MnDOT TMS" ON THE COVER FOR ITS PROJECTS.

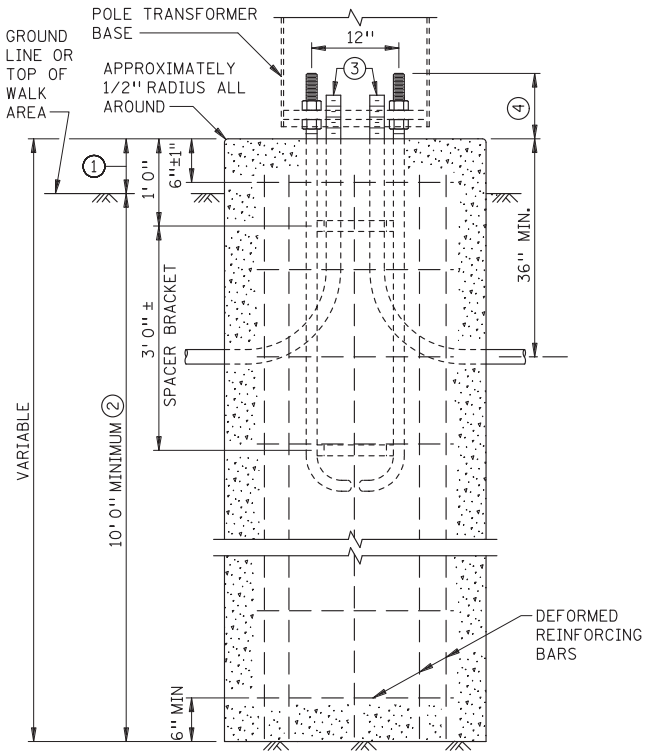
(1) 1" ± 1/4" CONCRETE ON INSIDE WALL OF ACCESS HOLES TO BE KNOCKED OUT AS NEEDED. A 3/4" HOLE IS PERMITTED IN KNOCKOUT WALLS FOR INSTALLATION.

(2) PLACE 4' X 4' X 1' COARSE FILTER AGGREGATE, SPEC. 3149 UNDER FOOTING.

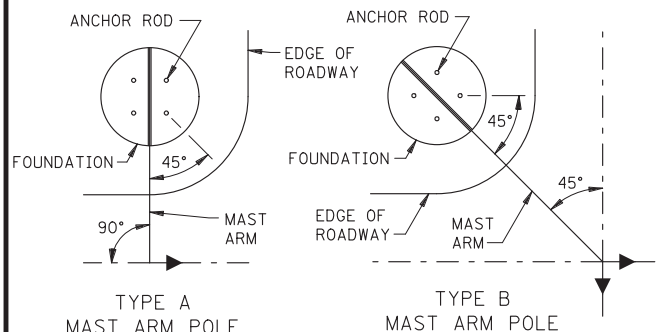
APPROVED JUNE 2, 2014 STATE DESIGN ENGINEER	STATE OF MINNESOTA DEPARTMENT OF TRANSPORTATION PRECAST CONCRETE HANDHOLE WITH VEHICLE LOAD	SPECIFICATION REFERENCE 3622	STANDARD PLATE NO. 8117G



TOP VIEW



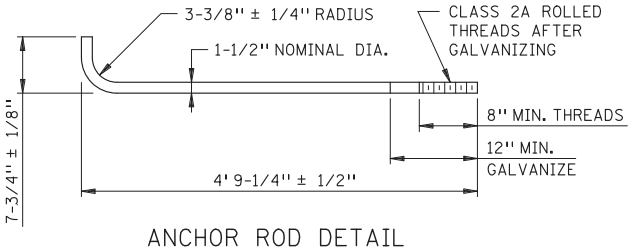
VERTICAL SECTION



TYPE A
MAST ARM POLE

TYPE B
MAST ARM POLE

ANCHOR ROD PLACEMENT
(WHEN USED WITH MAST ARM POLE)



ANCHOR ROD DETAIL
(SPEC. 3385 TYPE C)

NOTES:

REINFORCING BARS SHALL BE GRADE 60 AND MEET THE REQUIREMENTS OF ASTM A 706 (WELDABLE REBARS) AND ARE IDENTIFIED BY A DISTINGUISHING MARK OF "W" ROLLED ONTO THE SURFACE OF ONE SIDE OF THE BAR. WELDING SHALL BE PER ANSI/AWS D1.4. USE 8-NO. 7 BARS FOR VERTICAL REINFORCEMENT, SPACED ON A 27" DIA. CIRCLE. HORZONTAL (CIRCULAR) BARS TO BE NO. 4 SPACED AT 1' 0" MAXIMUM VERTICAL SPACING. SECURELY TIE OR WELD (OR COMBINATION) ALL REINFORCEMENT TOGETHER.

ANCHOR RODS SHALL BE GALVANIZED IN ACCORDANCE WITH SPEC. 3392 AND SHALL BE 1-1/2" NOMINAL DIA. AND CUT LENGTH OF 60" BEFORE BENDING. (SEE ANCHOR ROD DETAIL). ANCHOR ROD CAGES SHALL BE DESIGNED WITHOUT WELDING ONTO THE ANCHOR RODS.

ALL BACKFILLING AROUND THE FOUNDATION MUST BE IN ACCORDANCE WITH 2451.

ALL EXCAVATIONS MUST BE PROPERLY COMPACTED IN ACCORDANCE WITH 2451.

CONCRETE MIX 3G52.

PREFORMED JOINT FILLER SHALL BE USED BETWEEN FOUNDATION AND SIDEWALK OR CONCRETE AREAS.

A FIBER FORMING TUBE SHALL BE USED IN FORMING THE FOUNDATION, OR AS APPROVED BY THE ENGINEER.

OPEN ENDS OF ALL CONDUIT INTO FOUNDATION SHALL BE POSITIONED INSIDE THE ANCHOR ROD BOLT CIRCLE, AND CAPPED UNTIL CABLES ARE INSTALLED.

MAST ARM POLE STANDARDS SHALL NOT BE INSTALLED ON FOUNDATIONS UNTIL AT LEAST SEVEN DAYS OF CURING PERIOD HAVE ELAPSED.

ANTI-SEIZE COMPOUND THAT MEETS MIL-PRF-907E SPEC. SHALL BE APPLIED WITH A BRUSH TO ALL THREADS.

(1) THE ELEVATION OF THE TOP OF THE FOUNDATION SHALL ASSURE THAT THE VERTICAL CLEARANCE FROM THE BOTTOM OF ALL SIGNAL HEADS (INCLUDING BACKGROUND SHIELDS) TO THE PAVEMENT IS NOT LESS THAN 17 FT. NOR GREATER THAN 19 FT. THE TOP OF THE FOUNDATION MUST BE A MINIMUM OF 6" ABOVE THE GROUND LINE OR TOP OF SIDEWALK.

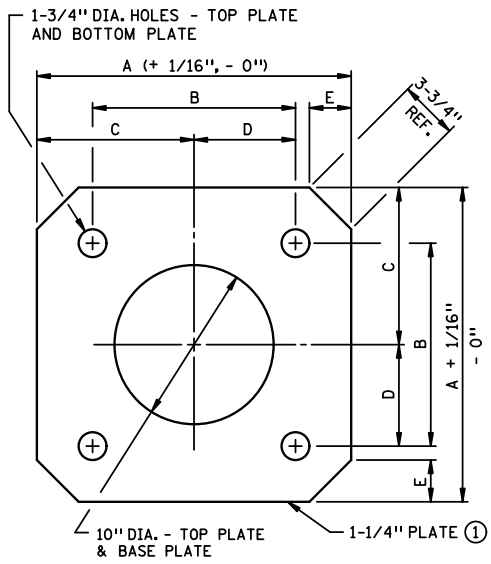
(2) DEPTH OF FOUNDATION MAY VARY IN PLANS OR SPECIAL PROVISIONS. DEPTH OF FOUNDATION MAY BE REDUCED 2 FEET WHEN PLACED IN SIDEWALK OR CONCRETE RAISED MEDIAN. FOUNDATION DEPTHS ARE BASED ON A SOIL FRICTION OF 30° AND A SOIL WEIGHT OF 120 LB/CF AND NO GROUNDWATER WITHIN THE GROUND SURFACE TO A DEPTH OF TWO TIMES THE WIDTH OR DIAMETER OF BOTTOM OF POLE FOUNDATION. A SOIL BORING OR CONE PENETRATION TEST (CPT) SOUNDING IS RECOMMENDED WHERE IN-SITU STRATIGRAPHY IS UNKNOWN OR QUESTIONABLE. ANY VARIATION IN THE DEPTH OF THE FOUNDATION REQUIRES AN APPROVAL BY THE DISTRICT SOILS ENGINEER.

(3) CONDUIT PER SPEC. 3801 OR 3803, SIZE AND NUMBER AS REQUIRED IN PLANS OR SPECIAL PROVISIONS, 4" MINIMUM AND 6" MAXIMUM PROJECTION ABOVE FOUNDATION, AND CAPPED UNTIL WIRING IS PLACED.

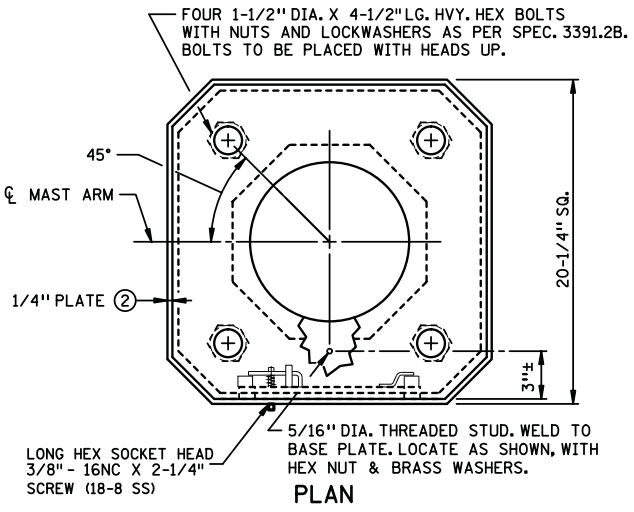
(4) 6" ANCHOR ROD PROJECTION (THREADED). SOME POLES (SUCH AS ROTATABLE T-BASE) MAY REQUIRE GREATER PROJECTION.

(5) FOUR ANCHOR RODS EQUALLY SPACED ON 16.97" DIA. BOLT CIRCLE (12" C. TO C.). EACH ANCHORAGE ROD SHALL HAVE TWO (2) HEAVY HEX LEVELING NUTS, AS PER ASTM A563 GRADE DH.

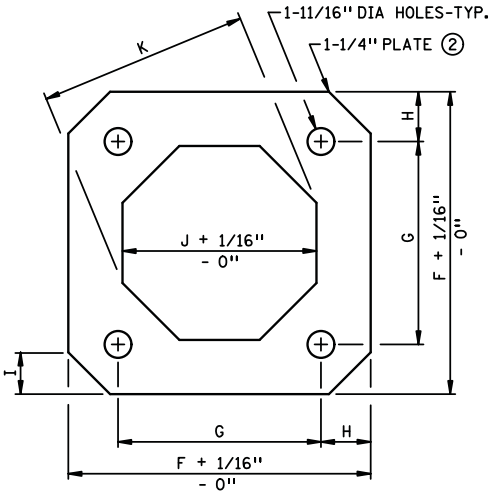
APPROVED JULY 15, 2015 STATE DESIGN ENGINEER	STATE OF MINNESOTA DEPARTMENT OF TRANSPORTATION POLE FOUNDATION (PA85)	SPECIFICATION REFERENCE 2565	STANDARD PLATE NO. 8120Q



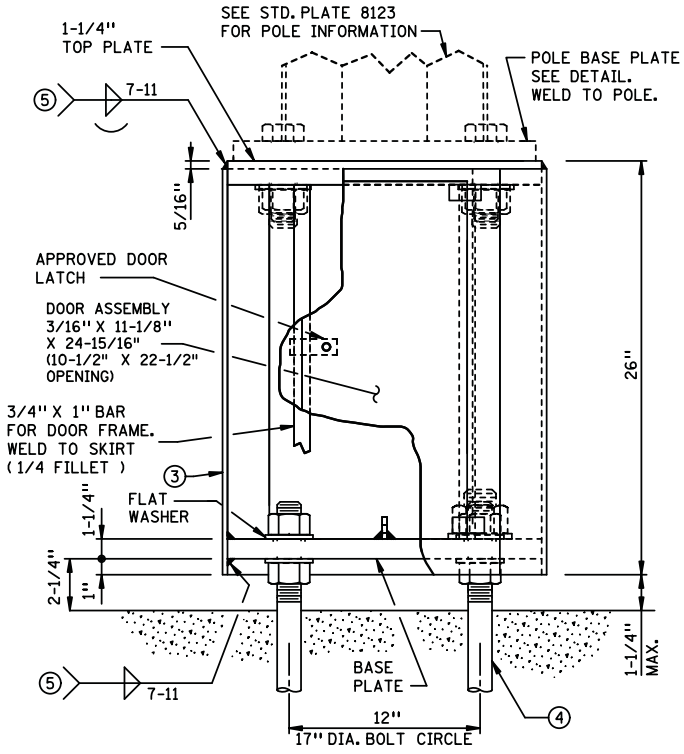
TOP & BASE PLATE DETAIL



PLAN



POLE BASE PLATE DETAIL



ELEVATION

DIMENSION	TOP (1) PLATE	BASE (1) PLATE	POLE (2) BASE PLATE
A	19-3/4"	19-3/4"	
B	12-3/4"	12"	
C	9-7/8"	9-7/8"	
D	6-3/8"	6"	
E	2-5/8"	2-5/8"	
F			19"
G			12-3/4"
H			3-1/8"
I			2-5/8"
J			12-3/16"
K			13-3/16"

NOTES:

ANTI-SEIZE COMPOUND THAT MEETS MIL-PRF-907E SPEC. SHALL BE APPLIED WITH A BRUSH TO ALL THREADS.

FOR SUBSTITUTION OF MATERIALS, SEE SPEC. 1605.

(1) STRUCTURAL STEEL AS PER SPEC. 3306.

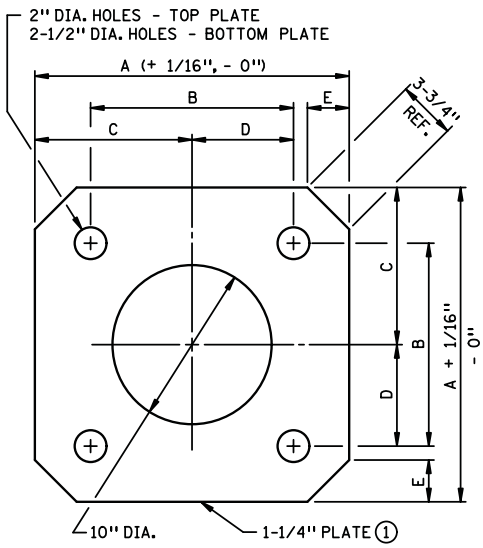
(2) STRUCTURAL STEEL AS PER SPEC. 3309.

(3) GALVANIZE TRANSFORMER BASE AS PER SPEC. 3394 AFTER FABRICATION. GALVANIZE ALL HARDWARE AS PER SPEC. 3392, EXCEPT STAINLESS STEEL AND BRASS.

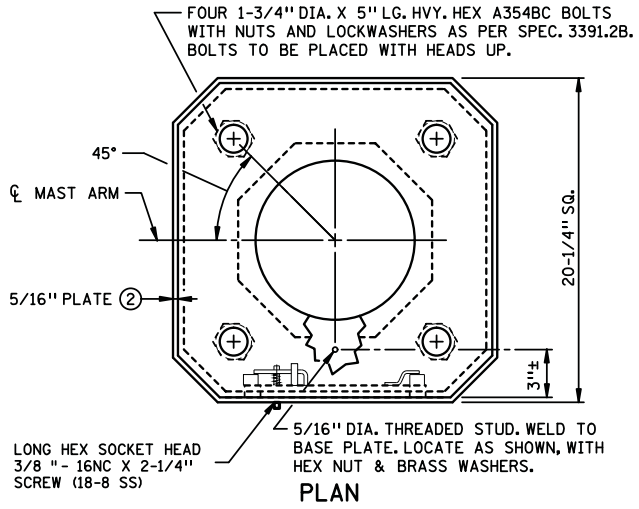
(4) SEE STANDARD PLATE 8120 FOR POLE FOUNDATION DETAILS.

(5) FABRICATE STRUCTURAL METALS PER SPEC. 2471.

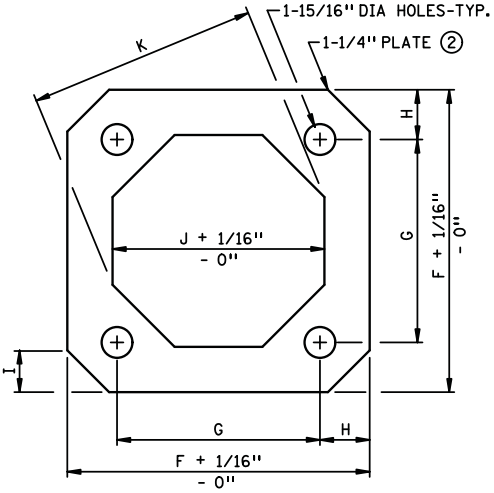
APPROVED APRIL 5, 2013 STATE DESIGN ENGINEER	STATE OF MINNESOTA DEPARTMENT OF TRANSPORTATION TRANSFORMER BASE AND POLE BASE PLATE (PA85)	SPECIFICATION REFERENCE 2565	STANDARD PLATE NO. 8121H 1 OF 2



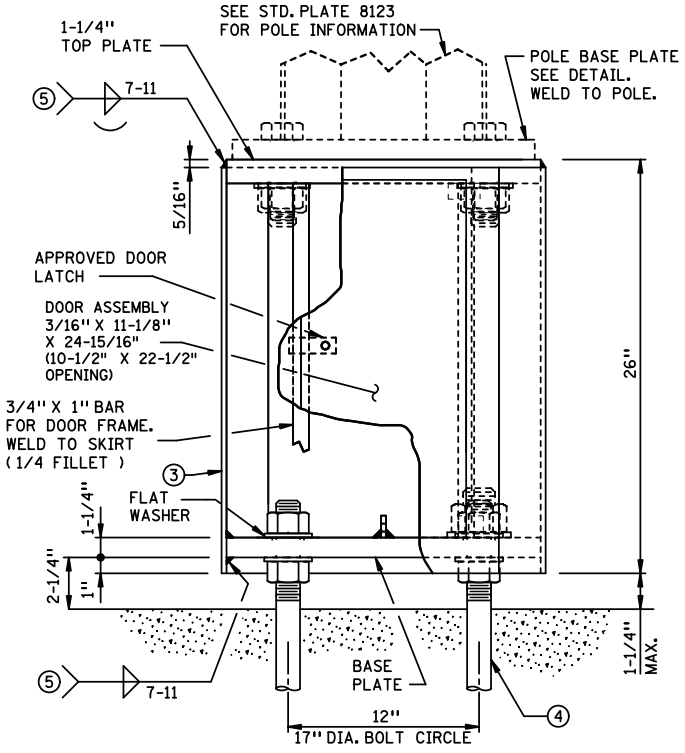
TOP & BASE PLATE DETAIL



PLAN



POLE BASE PLATE DETAIL



ELEVATION

DIMENSION	TOP (1) PLATE	BASE (1) PLATE	POLE (2) BASE PLATE
A	19-3/4"	19-3/4"	
B	12-3/4"	12"	
C	9-7/8"	9-7/8"	
D	6-3/8"	6"	
E	2-5/8"	2-5/8"	
F			19"
G			12-3/4"
H			3-1/8"
I			2-5/8"
J			13-3/16"
K			14-5/16"

NOTES:

ANTI-SEIZE COMPOUND THAT MEETS MIL-PRF-907E SPEC. SHALL BE APPLIED WITH A BRUSH TO ALL THREADS.

FOR SUBSTITUTION OF MATERIALS, SEE SPEC. 1605.

(1) STRUCTURAL STEEL AS PER SPEC. 3306.

(2) STRUCTURAL STEEL AS PER SPEC. 3309.

(3) GALVANIZE TRANSFORMER BASE AS PER SPEC. 3394 AFTER FABRICATION. GALVANIZE ALL HARDWARE AS PER SPEC. 3392, EXCEPT STAINLESS STEEL AND BRASS.

(4) SEE STANDARD PLATE 8126 FOR POLE FOUNDATION DETAILS.

(5) FABRICATE STRUCTURAL METALS PER SPEC. 2471.

APPROVED APRIL 5, 2013

STATE DESIGN ENGINEER

STATE OF MINNESOTA
DEPARTMENT OF TRANSPORTATION

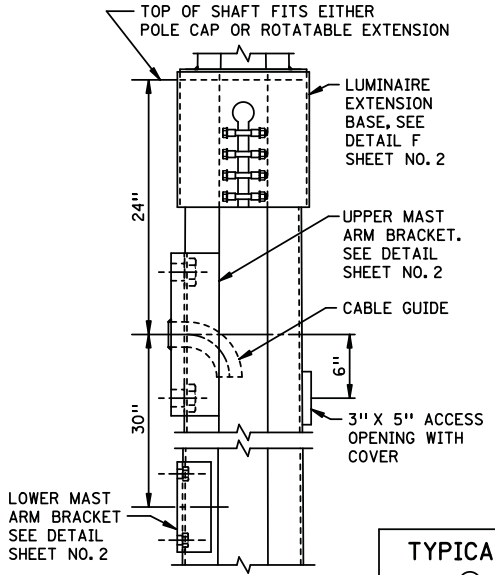
TRANSFORMER BASE AND POLE BASE PLATE

(PA90 AND PA100)

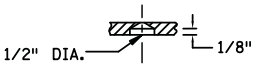
SPECIFICATION REFERENCE 2565

STANDARD PLATE NO. 8121H

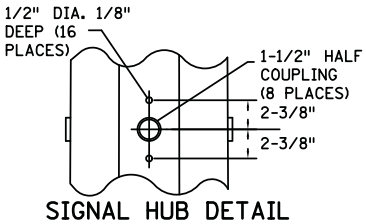
2 OF 2



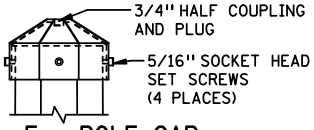
ENLARGED DETAIL A



COUNTERSINK DETAIL

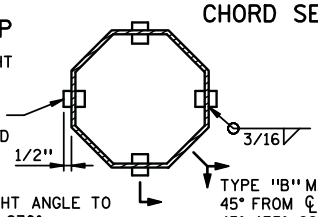


SIGNAL HUB DETAIL



DETAIL E - POLE CAP

SIGNAL HUB COUPLINGS AT RIGHT ANGLE TO THE ℄ OF ROADWAY. PLUGS SHALL BE PROVIDED FOR ALL COUPLINGS FOUR (4) 1-1/2" DIA. COUPLINGS, INSIDE THREADED



TYPE "A" MAST ARM AT RIGHT ANGLE TO ℄ OF ROADWAY, 0°, 90°, 180°, 270°

TYPE "B" MAST ARM AT 45° FROM ℄ OF ROADWAY 45°, 135°, 225°, 315°

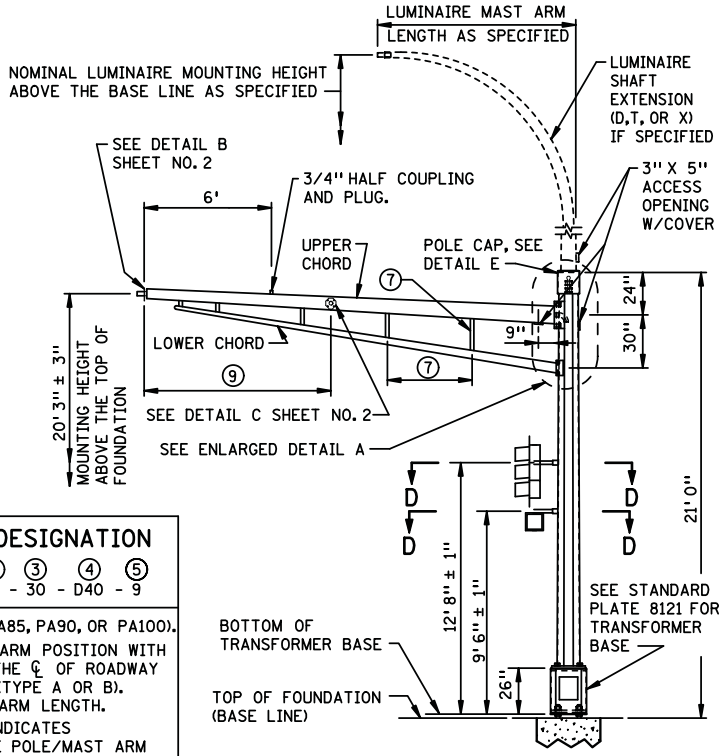
SECTION D-D
POLE MOUNTED SIGNAL HUB ②

TYPICAL DESIGNATION

① ② ③ ④ ⑤
TYPE PA90 - A - 30 - D40 - 9

① POLE TYPE (PA85, PA90, OR PA100).
② SIGNAL MAST ARM POSITION WITH RESPECT TO THE ℄ OF ROADWAY SECTION D-D (TYPE A OR B).
③ SIGNAL MAST ARM LENGTH.
④ THE LETTER INDICATES THE LUMINAIRE POLE/MAST ARM TYPE (D=DAVIT, T=TRUSS, X=STRAIGHT). THE NUMBER INDICATES THE NOMINAL LUMINAIRE MOUNTING HEIGHT FROM THE BASELINE.
⑤ LUMINAIRE MAST ARM LENGTH.

POLE-UPPER & LOWER CHORD SECTION



POLE AND MAST ARM

TAPERED OCTAGONAL MAST ARM TRUSS AND POLE DIMENSIONS

POLE TYPE	MAST ARM LENGTH ⑧	VERTICAL POLE ⑥			UPPER CHORD ⑥			LOWER CHORD ⑥		
		LARGE END	SMALL END	WALL THICK	LARGE END	SMALL END	WALL THICK	LARGE END	SMALL END	WALL THICK
PA85	15'-30'	13.0"	11.8"	0.179"	9.6"	4.0"	0.120"	5.6"	2.8"	0.120"
PA90	30'-40'	14.0"	11.8"	0.250"	10.9"	5.0"	0.179"	5.6"	2.8"	0.120"
PA100	40'-55'	14.0"	11.8"	0.312"	11.6"	5.0"	0.250"	5.6"	2.8"	0.120"

NOTES:

MATERIAL: HIGH STRENGTH LOW ALLOY STEEL SPEC. 3310 50,000 PSI MINIMUM YIELD.

GALVANIZED STRUCTURAL STEEL AS PER SPEC. 3394 AFTER FABRICATION. GALVANIZE ALL HARDWARE AS PER SPEC. 3392. PROVIDE VENT HOLES FOR GALVANIZING.

VERTICAL POST AND MAST ARM ELEMENTS SHALL BE OCTAGONAL TUBE, FABRICATED BY LONGITUDINAL SEAM WELDING WITH 60% PENETRATION.

EACH MAST ARM POLE STANDARD CONSTRUCTED IN ACCORDANCE WITH THIS SPECIFICATION SHALL BE IDENTIFIED BY THE MARKING "PA85, PA90 OR PA100" IMPRINTED INTO THE VERTICAL POST SHAFT APPROXIMATELY 6 FEET ABOVE THE BOTTOM OF THE TRANSFORMER BASE ON THE ZERO-DEGREE FACE WITH RESPECT TO THE TRAFFIC SIGNAL TRUSS-TYPE MAST ARM. THE IMPRINTED "PA85, PA90 OR PA100" SHALL BE CLEARLY LEGIBLE AFTER GALVANIZATION.

THE BASE LINE OR TOP OF FOUNDATION IS ESTABLISHED AT TOP OF THE FINISHED PAVEMENT BENEATH THE OUTER END OF THE MAST ARM.

SEE SPEC. 1605 FOR SUBSTITUTION OF MATERIALS.

SEE SPEC. 2471 FOR FABRICATION REQUIREMENTS.

THE MOUNTING HEIGHTS OF LUMINAIRES ARE MEASURED FROM THE BASELINE, WHICH PROVIDE MOUNTING HEIGHTS OF 30' TO 50'.

⑥ DIMENSION MEASURED OUTSIDE POINT TO OUTSIDE POINT THROUGH OCTAGON CENTER. ADJUST POLE WITH LEVELING NUTS SO THAT THE POLE IS VERTICAL.

⑦ VERTICAL BRACES SHALL BE SPACED AT 5' INTERVALS. MINIMUM SECTION FOR VERTICAL BRACE SHALL BE 1" SCHEDULE 40 PIPE WITH ALLOWABLE STRESS OF 42000 PSI. PIPE ENDS SHALL BE FLATTENED TO A MAXIMUM THICKNESS OF 1" PERPENDICULAR TO THE MAST ARM AXIS.

⑧ ALL ARMS SHALL BE SUPPLIED IN FIVE-FOOT INCREMENTS OF LENGTH.

⑨ ONE MID-MAST ARM MOUNT SHALL BE PLACED AT 11' FROM THE END FOR 30', 35' AND 40' LENGTH MAST ARMS. TWO MID MAST ARM MOUNTS SHALL BE PLACED AT 11' AND 23' FROM THE END FOR 45', 50' AND 55' LENGTH MAST ARMS. ALL MID-MAST ARMS SHALL BE CAPPED AND GALVANIZED. KEEP UNUSED MID-MAST ARM MOUNTS CAPPED AND GALVANIZED.

APPROVED DECEMBER 20, 2011

STATE DESIGN ENGINEER

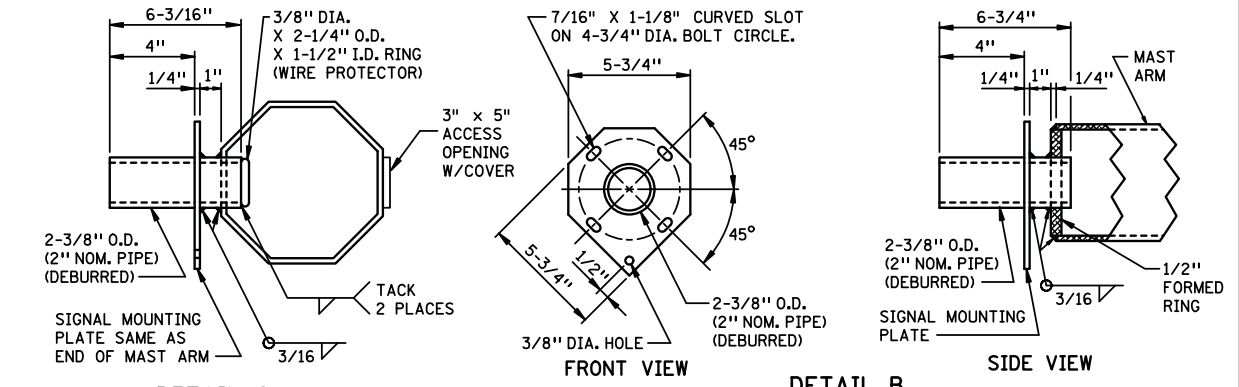
STATE OF MINNESOTA
DEPARTMENT OF TRANSPORTATION

POLE AND MAST ARM

LUMINAIRES AND TRAFFIC LIGHTS ASSEMBLY
(FOR ALL POLE TYPES)

SPECIFICATION REFERENCE
2565

STANDARD PLATE NO.
8123G
1 OF 2

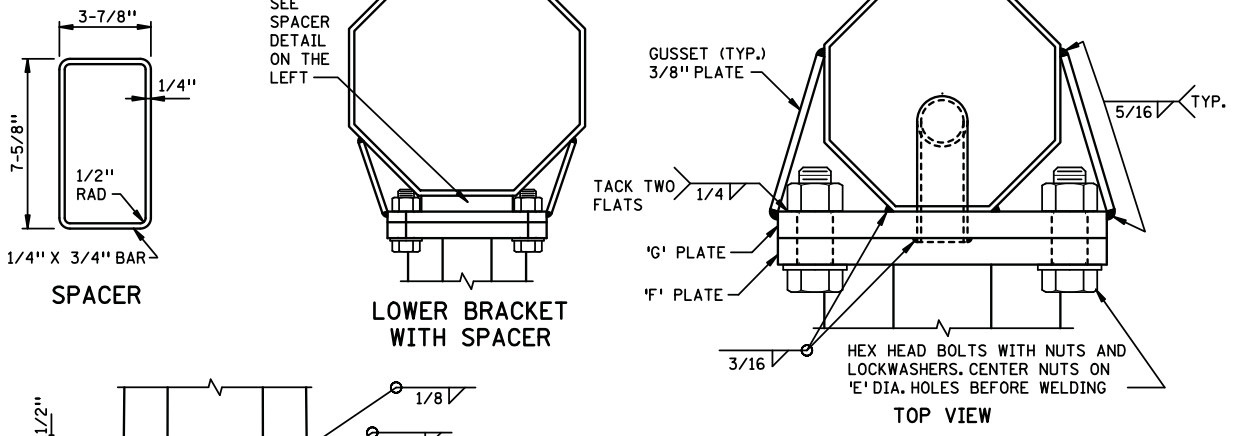


DETAIL C
MID MAST ARM

FRONT VIEW

SIDE VIEW

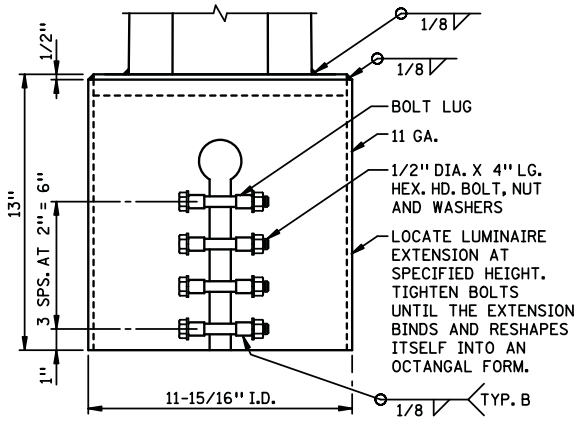
DETAIL B
SIGNAL MOUNTING PLATE



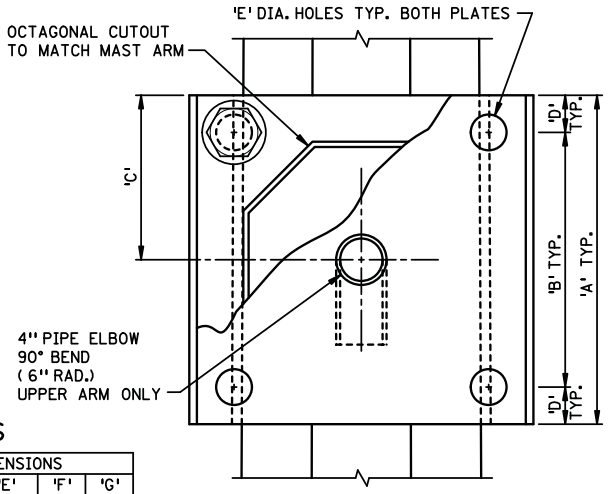
SPACER

LOWER BRACKET
WITH SPACER

TOP VIEW



DETAIL F
LUMINAIRE EXTENSION BASE



ELEVATION

UPPER & LOWER
MAST ARM BRACKET

ARM AND POLE MOUNTING BRACKETS

ARM MEMBER	FOUR HEX HEAD BOLTS & NUTS EACH BRACKET	TABULATED BRACKET DIMENSIONS						
		'A'	'B'	'C'	'D'	'E'	'F'	'G'
UPPER	1-1/2"-6UNC X 4-1/2" LG.	15.50"	12.00"	7.75"	1.75"	1.688"	1.25"	1.25"
LOWER	3/4"-10UNC X 2-1/4" LG. ①	(V) 8.50" (H) 7.75"	6.25" 5.75"	4.25" 3.87"	1.125" 1.0"	0.875" 0.875"	3/4" 3/4"	1/2" 1/2"

NOTES:

① THE (V) DIMENSIONS ARE MEASURED VERTICALLY AND THE (H) DIMENSIONS ARE MEASURED HORIZONTALLY, WHILE UNSPECIFIED ARE MEASURED BOTH VERTICALLY AND HORIZONTALLY.

APPROVED DECEMBER 20, 2011

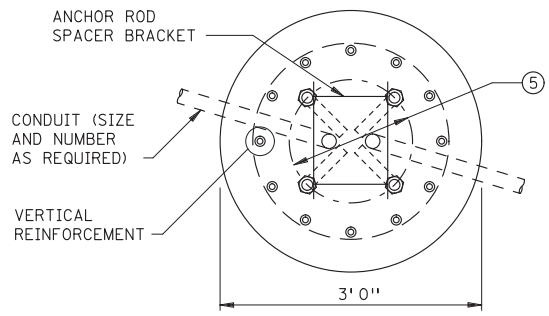
STATE DESIGN ENGINEER

STATE OF MINNESOTA
DEPARTMENT OF TRANSPORTATION

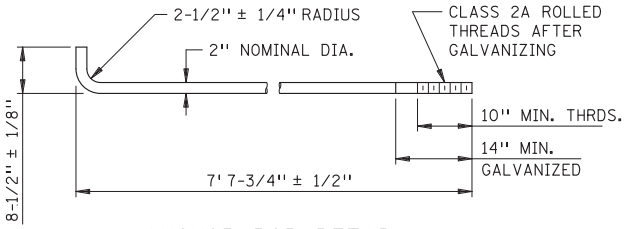
POLE AND MAST ARM
(DETAILS)

SPECIFICATION REFERENCE
2565

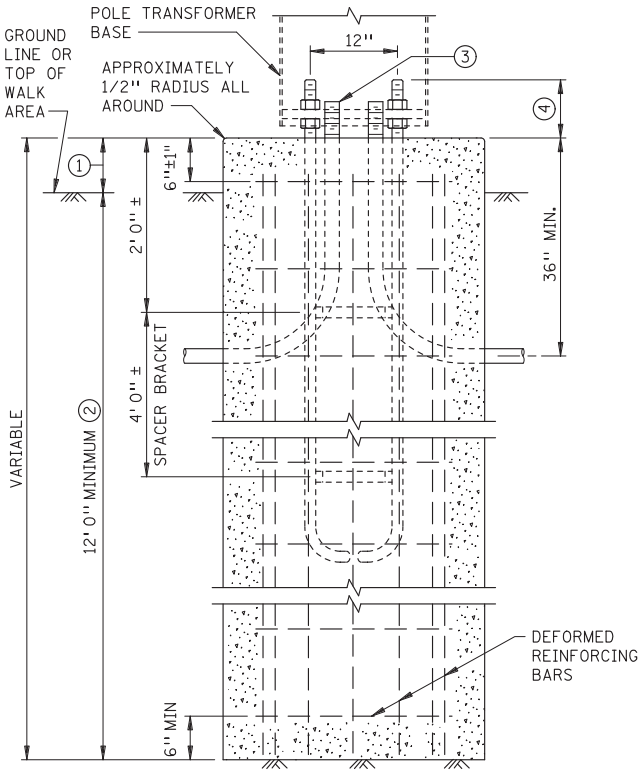
STANDARD PLATE NO.
8123G
2 OF 2



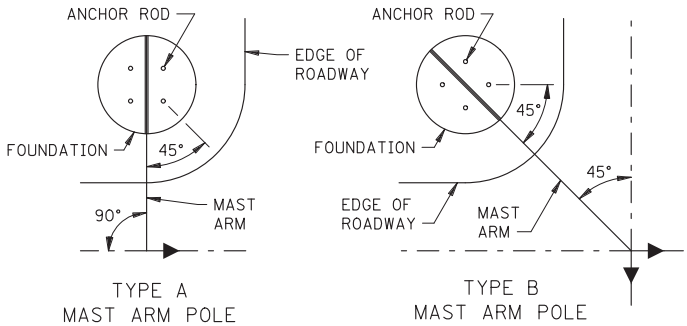
TOP VIEW



ANCHOR ROD DETAIL
(SPEC. 3385 TYPE C)



VERTICAL SECTION



TYPE A
MAST ARM POLE

TYPE B
MAST ARM POLE

ANCHOR ROD PLACEMENT
(WHEN USED WITH MAST ARM POLE)

NOTES:

REINFORCING BARS SHALL BE GRADE 60 AND MEET THE REQUIREMENTS OF ASTM A 706 (WELDABLE REBARS) AND ARE IDENTIFIED BY A DISTINGUISHING MARK OF "W" ROLLED ONTO THE SURFACE OF ONE SIDE OF THE BAR. WELDING SHALL BE PER ANSI/AWS D1.4. USE 12-NO. 7 BARS FOR VERTICAL REINFORCEMENT, SPACED ON A 28" DIA. CIRCLE. HORIZONTAL (CIRCULAR) BARS TO BE NO. 4 SPACED AT 1'-0" MAXIMUM VERTICAL SPACING. SECURELY TIE OR WELD (OR COMBINATION) ALL REINFORCEMENT TOGETHER.

ANCHOR RODS SHALL BE GALVANIZED IN ACCORDANCE WITH SPEC. 3392 AND SHALL BE 2" NOM. DIA. AND CUT LENGTH OF 96" BEFORE BENDING. (SEE ANCHOR ROD DETAIL). ANCHOR ROD CAGES SHALL BE DESIGNED WITHOUT WELDING.

ANTI-SIEZE COMPOUND THAT MEETS MIL-PRF-907E SPEC. SHALL BE APPLIED WITH A BRUSH TO ALL THREADS.

ALL BACKFILLING AROUND THE FOUNDATION MUST BE IN ACCORDANCE WITH 2451.

ALL EXCAVATION MUST BE PROPERLY COMPACTED IN ACCORDANCE WITH 2451.

CONCRETE MIX SHALL BE 3G52.

PREFORMED JOINT FILLER SHALL BE USED BETWEEN FOUNDATION AND SIDEWALK OR CONCRETE AREAS.

FIBER FORMING TUBE SHALL BE USED IN FORMING THE FOUNDATION, OR AS APPROVED BY THE ENGINEER.

OPEN ENDS OF ALL CONDUIT INTO FOUNDATION SHALL BE THREADED, POSITIONED INSIDE THE ANCHOR ROD BOLT CIRCLE, AND CAPPED UNTIL CABLES ARE PLACED.

MAST ARM POLE STANDARDS SHALL NOT BE PLACED ON FOUNDATIONS UNTIL AT LEAST SEVEN DAYS OF CURING PERIOD HAVE ELAPSED.

(1) THE ELEVATION OF THE TOP OF THE FOUNDATION SHALL ASSURE THAT THE VERTICAL CLEARANCE FROM THE BOTTOM OF ALL SIGNAL HEADS (INCLUDING BACKGROUND SHIELDS) TO THE PAVEMENT IS NOT LESS THAN 17 FEET NOR GREATER THAN 19 FEET. THE TOP OF THE FOUNDATION MUST BE A MINIMUM OF 6" ABOVE THE GROUND LINE OR TOP OF SIDEWALK.

(2) DEPTH OF FOUNDATION MAY VARY IN PLANS OR SPECIAL PROVISIONS. DEPTH OF FOUNDATION MAY BE REDUCED 2 FEET WHEN PLACED IN SIDEWALK OR CONCRETE RAISED MEDIAN. FOUNDATION DEPTHS ARE BASED ON A SOIL FRICTION ANGLE OF 30° AND A SOIL WEIGHT OF 120 LB/CF AND NO GROUNDWATER WITHIN THE GROUND SURFACE TO A DEPTH OF TWO TIMES THE WIDTH OR DIAMETER OF BOTTOM OF POLE FOUNDATION. A SOIL BORING OR CONE PENETRATION TEST (CPT) SOUNDING IS RECOMMENDED WHERE IN-SITU STRATIGRAPHY IS UNKNOWN OR QUESTIONABLE. ANY VARIATION IN THE DEPTH OF THE FOUNDATION REQUIRES AN APPROVAL BY THE SOILS ENGINEER.

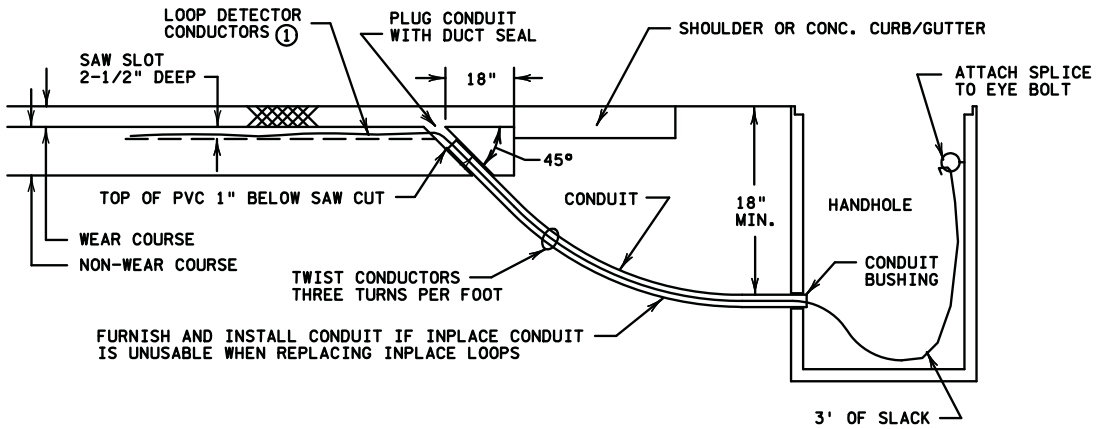
(3) CONDUIT PER SPEC. 3801 OR 3803. SIZE AND NUMBER AS REQUIRED IN PLANS OR SPECIAL PROVISIONS. 4" MINIMUM AND 6" MAXIMUM PROJECTION ABOVE FOUNDATION, AND CAPPED UNTIL WIRING IS PLACED.

(4) 8" ANCHOR ROD PROJECTION (THREADED). SOME POLES (SUCH AS ROTATABLE T-BASE) REQUIRE GREATER PROJECTION.

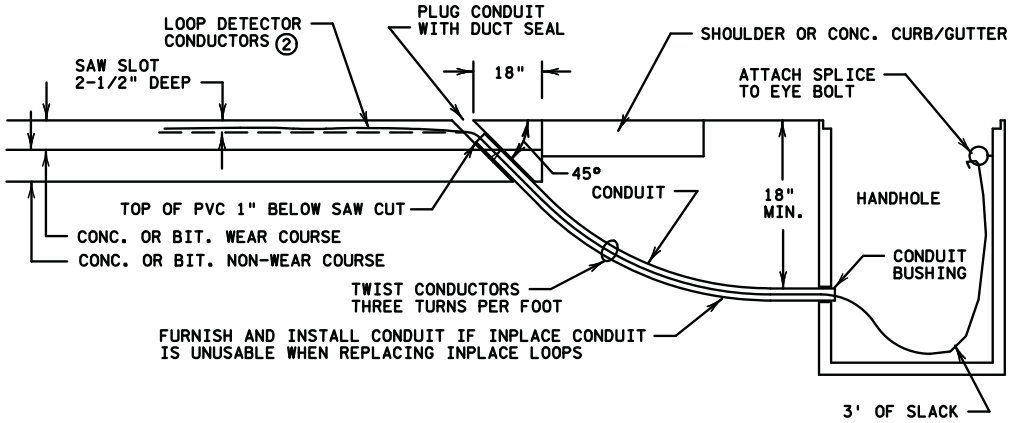
(5) FOUR ANCHOR RODS EQUALLY SPACED ON 16.97" DIA. BOLT CIRCLE (12" C. TO C.). EACH ANCHORAGE ROD SHALL HAVE TWO (2) HEAVY HEX LEVELING NUTS, PER ASTM A563 GRADE DH.

APPROVED JULY 15, 2015 STATE DESIGN ENGINEER	STATE OF MINNESOTA DEPARTMENT OF TRANSPORTATION **POLE FOUNDATION** (PA90 AND PA100)	SPECIFICATION REFERENCE 2565	STANDARD PLATE NO. **8126L**

MILL & OVERLAY CONSTRUCTION



INPLACE ROADWAYS



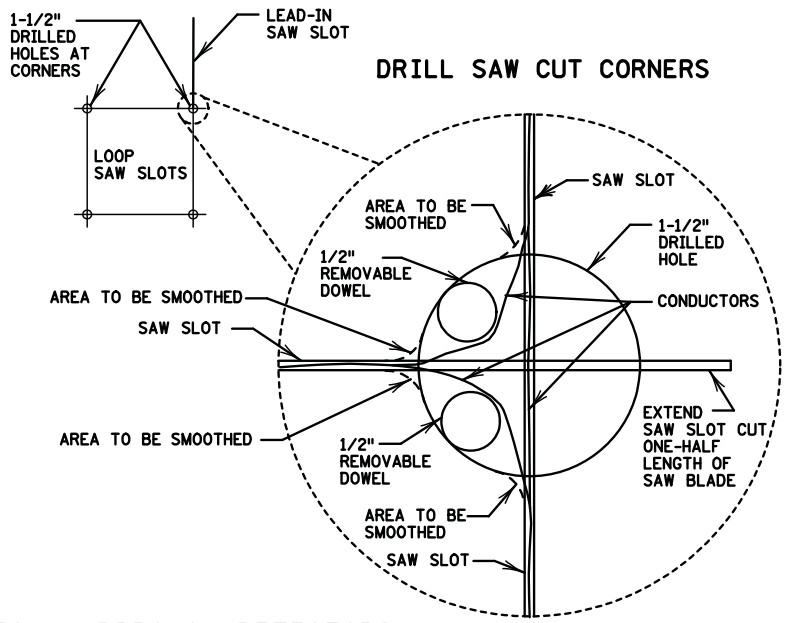
NOTES:

SEE SHEET 3 FOR ADDITIONAL NOTES

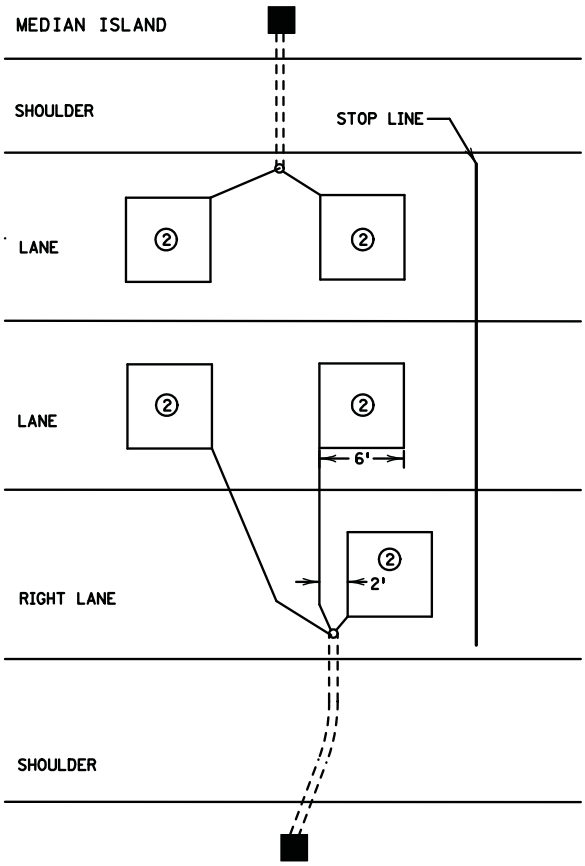
① SAW CUT LOOP DETECTOR BETWEEN NON-WEAR AND WEAR COURSES

② SAW CUT LOOP DETECTOR INTO WEAR COURSE OR CONC. SURFACE

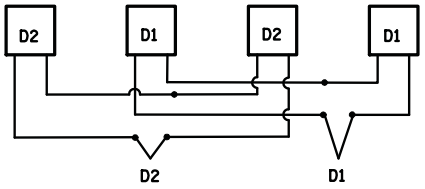
APPROVED DECEMBER 11, 2009 STATE DESIGN ENGINEER	STATE OF MINNESOTA DEPARTMENT OF TRANSPORTATION **SAW CUT LOOP DETECTORS** LOOP/HANDHOLE INSTALLATION	SPECIFICATION REFERENCE 2565	STANDARD PLATE NO. 8130E 1 OF 3



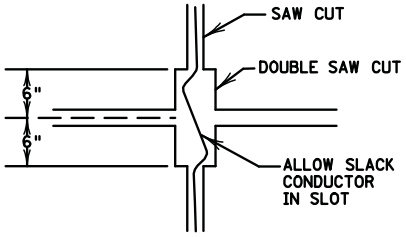
TYPICAL APPROACH DETECTORS ②



MULTIPLE LOOP SERIES HOOKUP



JOINT/CRACK INSTALLATION ①



NOTES:

SEE SHEET 3 FOR ADDITIONAL NOTES.

① LOOP LEADS SHALL NOT CROSS TRANSVERSE JOINTS IN CONCRETE PAVEMENT. MOVE A LOOP TO THE NEXT PANEL AND INSTALL A SEPARATE CONDUIT TO THE HANDHOLE IF ALL LOOPS WILL NOT FIT ONE PANEL AND MAINTAIN SEPARATIONS SHOWN.

② SEE PLAN LAYOUT FOR ACTUAL DETECTOR SIZE AND PLACEMENT LOCATION.

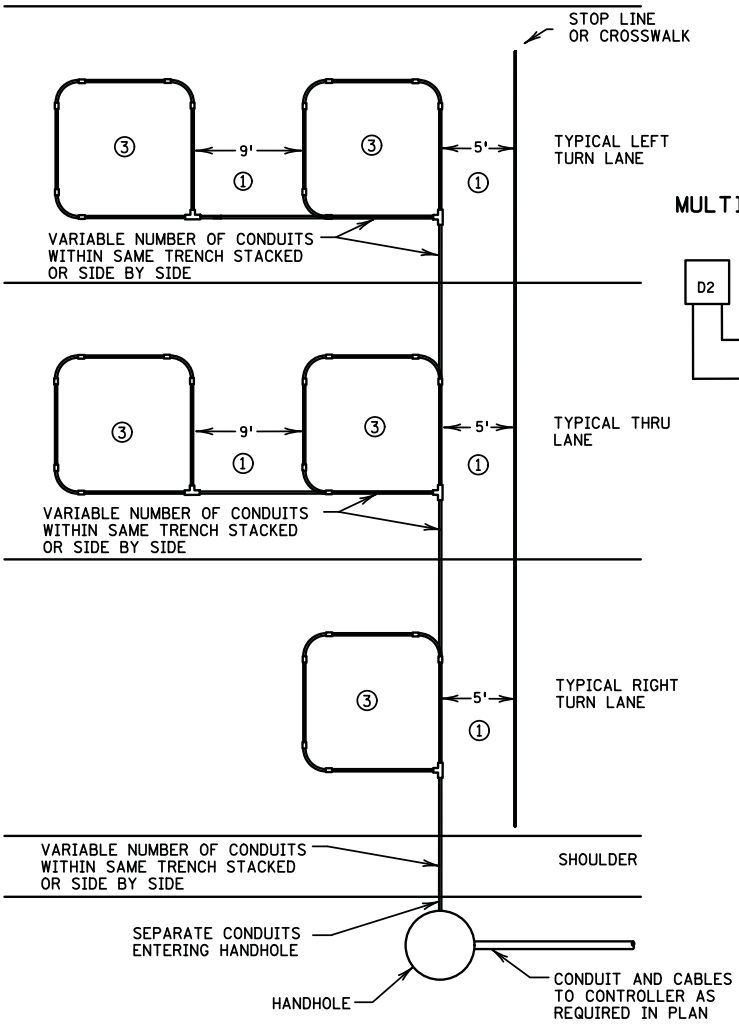
APPROVED DECEMBER 11, 2009 STATE DESIGN ENGINEER	STATE OF MINNESOTA DEPARTMENT OF TRANSPORTATION SAW CUT LOOP DETECTORS DETAILS	SPECIFICATION REFERENCE 2565	STANDARD PLATE NO. 8130E 2 OF 3

NOTES:

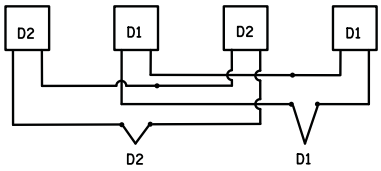
1. WHERE LOOP DETECTORS ARE TO BE FURNISHED AND INSTALLED AND THE ROADWAYS ARE TO BE SURFACED WITH NEW BITUMINOUS PAVEMENT, THE LOOP DETECTORS SHALL BE SAW CUT IN THE ROADWAY AND SEALANT MATERIAL PLACED TO THE SATISFACTION OF THE ENGINEER BEFORE THE BITUMINOUS WEARING COURSE IS PLACED BY THE BITUMINOUS PAVING CONTRACTOR; HOWEVER, THE ENGINEER MAY DIRECT THE CONTRACTOR NOT TO PLACE THE LOOP DETECTORS IN THE ROADWAY UNTIL PAVEMENT MARKINGS AND LANE STRIPING HAS BEEN DETERMINED AND/OR PLACED.
2. AREA TO BE SAW CUT SHALL BE THOROUGHLY CLEANED BY SWEEPING, WASHING, OR BLOWING SURFACE CLEAR OF DIRT AND DEBRIS.
3. LOOP DETECTORS AND LOOP DETECTOR HOME-RUN WILL BE MARKED ON PAVEMENT BY THE ENGINEER OR BY THE CONTRACTOR AS DIRECTED.
4. LOOP DETECTOR SAW CUTS SHALL BE A UNIFORM DEPTH OF 2-1/2" +/- 1/4" AND 1/8" WIDER THAN THE OUTER DIAMETER OF THE TUBING.
5. THE CONTRACTOR SHALL AVOID CROSSING CONCRETE JOINTS OR CRACKS. HOWEVER, IF A CONCRETE JOINT OR CRACK MUST BE CROSSED, THE CONTRACTOR SHALL USE THE JOINT/CRACK DETAIL SHOWN ON SHEET 2 OF 3.
6. ALL LOOP CORNERS SHALL BE SQUARE. CORNERS SHALL BE DRILLED WITH 1-1/2" DIAMETER DRILL TO A DEPTH OF 1/4" DEEPER THAN SAW CUT. CORNERS SHALL BE ROUNDED TO PREVENT DAMAGE TO THE CONDUCTORS OR TUBING.
7. ALL LOOP DETECTOR SAW CUTS SHALL BE CLEANED AND FLUSHED OF FOREIGN MATERIAL USING A COMBINATION OF AIR AND WATER, AND DRIED WITH COMPRESSED AIR PRIOR TO INSTALLATION OF LOOP DETECTOR CONDUCTORS. DRY SAWING DOES NOT REQUIRE WATER FLUSHING, HOWEVER, THE SAW CUT SHALL BE CLEANED OF ALL FOREIGN MATERIAL.
8. THE CONTRACTOR SHALL FURNISH AND INSTALL FROM THE END OF THE SAW-CUT TO THE ADJACENT HANDHOLE A MINIMUM OF A 3/4" CONDUIT FOR A SINGLE LOOP DETECTOR OR AN APPROPIATE SIZED CONDUIT BASED ON N.E.C. FILL RATIONS FOR 2 OR MORE LOOP DETECTORS.
9. BEFORE INSTALLATION OF LOOP DETECTOR CONDUCTORS, THE CONTRACTOR SHALL PLACE A BEAD OF APPROVED LOOP DETECTOR SEALANT IN SAW CUT SLOT TO WITHIN 6" OF THE CONDUIT THAT RUNS FROM THE END OF THE SAW-CUT TO THE ADJACENT HANDHOLE.
10. THE CONTRACTOR SHALL PLACE THE CLEAN AND DRIED LOOP DETECTOR CONDUCTORS CONTINUOUS WITH 4 TURNS OF WIRE AND WOUND IN A CLOCKWISE DIRECTION.
11. THE LOOP DETECTOR CONDUCTORS SHALL BE PUSHED TO THE BOTTOM OF THE SAW-CUT WITH A BLUNT INSTRUMENT TO AVOID DAMAGING TUBING OR CONDUCTORS. THE CONTRACTOR SHALL INSTALL 3/4" DIAMETER BY 2" BACKER ROD AT 2' INTERVALS TO ENSURE THAT THE CONDUCTORS ARE AT THE BOTTOM OF THE SAW CUT.
12. LOOP DETECTOR CONDUCTORS SHALL BE TWISTED 3 TURNS PER FOOT THROUGH THE CONDUIT TO THE SPLICE IN THE HANDHOLE.
13. LOOP DETECTOR LEAD-IN CONDUIT SHALL BE SEALED WITH DUCT SEAL OR OTHER APPROVED SEAL TO PREVENT LOOP DETECTOR SEALANT FROM ENTERING CONDUIT.
14. SEAL LOOP DETECTOR CONDUCTORS WITH A MN/DOT APPROVED LOOP DETECTOR SEALANT AS LISTED ON THE MN/DOT APPROVED PRODUCTS LIST (APL) AND IN ACCORDANCE WITH THE MANUFACTURER'S INSTRUCTIONS.
15. THE LOOP DETECTOR ROADWAY CONDUCTORS AND THE LOOP DETECTOR LEAD-IN CABLE CONDUCTORS SHALL BE PROPERLY PREPARED AND CLEANED BEFORE SPLICING. ROUGHEN CABLE JACKET WITH SAND PAPER TO ENSURE GOOD ADHESION WITH SPLICE KIT.
16. LOOP DETECTORS SHALL BE SPLICED USING AN APPROVED SPLICE KIT AS LISTED ON THE MN/DOT APPROVED PRODUCTS LIST (APL). MN/DOT APPROVED SPLICE KITS SHALL BE INSTALLED, EITHER ACCORDING TO MANUFACTURES INSTRUCTIONS, OR BY AN ALTERNATE METHOD APPROVED BY THE ENGINEER.
17. PRIOR TO FURNISHING AND INSTALLING THE APPROVED LOOP DETECTOR SPLICE KIT, THE CONTRACTOR SHALL SOLDER THE ENDS OF THE LOOP DETECTOR LEAD-IN CONDUCTORS TO THE ROADWAY LOOP DETECTOR CONDUCTORS, AND SHALL FURNISH AND INSTALL AN APPROPRIATE SIZED WIRE NUT TO THE SOLDERED ENDS PRIOR TO INSTALLATION OF THE SPLICE KIT.
18. SPLICE KITS SHALL BE FURNISHED AND INSTALLED IN HANDHOLES IN SUCH A MANNER AS TO ENSURE THAT EACH SPLICE KIT IS SUSPENDED AND/OR SECURED NEAR THE TOP OF THE HANDHOLE TO THE SATISFACTION OF THE ENGINEER (PLACING SPLICE KITS ON TOP OF THE ELECTRICAL CABLES AND CONDUCTORS IS NOT ACCEPTABLE).

APPROVED DECEMBER 11, 2009 STATE DESIGN ENGINEER	STATE OF MINNESOTA DEPARTMENT OF TRANSPORTATION SAW CUT LOOP DETECTORS NOTES	SPECIFICATION REFERENCE 2565	STANDARD PLATE NO. 8130E 3 OF 3

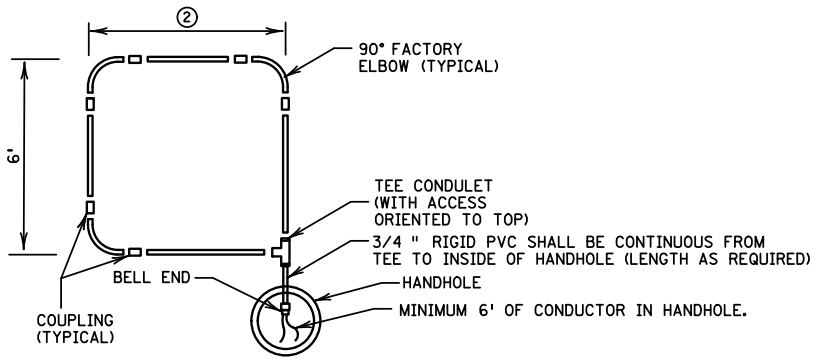
TYPICAL CROSS STREET RIGID PVC LOOP DETECTOR LAYOUT



MULTIPLE LOOP SERIES HOOKUP



TYPICAL RIGID PVC LOOP DETECTOR DETAIL



NOTES:

SEE SHEET 2 OF 3 FOR ADDITIONAL NOTES.

① DIMENSION SHOWN IS TYPICAL. USE GIVEN DIMENSION INDICATED ON PLAN LAYOUT.

② THIS DIMENSION MAY VARY ACCORDING TO LOOP SIZE ON PLAN LAYOUT.

③ 6' x 6' RIGID PVC LOOP DETECTOR (CENTERED IN THE LANE).

APPROVED DECEMBER 20, 2011 STATE DESIGN ENGINEER	STATE OF MINNESOTA DEPARTMENT OF TRANSPORTATION PREFORMED RIGID PVC CONDUIT LOOP DETECTOR LAYOUT DETAILS	SPECIFICATION REFERENCE 2357 2360 2565	STANDARD PLATE NO. 8132B 1 OF 3

NOTES:

ROADWAY LOOP DETECTOR CONDUCTORS AND LOOP DETECTOR LEAD-IN CABLES SHALL BE IN ACCORDANCE WITH SPEC 3815.

THE 3/4" RIGID PVC CONDUIT AND FITTINGS SHALL BE SCHEDULE 40. SEE SPEC. 3803.

THREE CORNERS OF EACH LOOP DETECTOR SHALL BE A 90° FACTORY ELBOW (6" RADIUS). THE FOURTH SHALL BE A RIGID PVC TEE CONDULET.

APPROVED RIGID PVC PRIMER AND CEMENT SHALL BE USED FOR THE RIGID PVC JOINTS.

ALL SLACK MUST BE REMOVED FROM LOOP DETECTOR CONDUCTORS WITHIN THE RIGID PVC.

THE ROADWAY LOOP DETECTOR CONDUCTORS (1/C#14) SHALL BE TWISTED THREE TURNS PER FOOT FROM THE RIGID PVC TEE CONDULET TO THE HANDHOLE.

ATTACH A FERROUS METAL ITEM IN OR ADJACENT TO THE TEE CONDULET COVER OR AS DIRECTED BY THE ENGINEER.

EACH LOOP DETECTOR CONDUIT TO THE HANDHOLE SHALL BE SLOPED TOWARDS THE HANDHOLE.

LOOP DETECTOR CONDUITS TO THE HANDHOLE MAY BE PLACED WITHIN THE SAME TRENCH.

THE LOOP DETECTOR ROADWAY CONDUCTORS SHALL EXTEND 6' TO 10' INTO THE HANDHOLE FOR SPLICING.

NO SPLICES SHALL BE ALLOWED IN CONDUIT.

IF BENDING OF THE RIGID PVC LOOP LEAD-IN CONDUIT IS REQUIRED, AN APPROPRIATE HEATING BLANKET OR DEVICE APPROVED BY THE ENGINEER SHALL BE USED. EXPOSED FLAME OR TORCHES ARE NOT ALLOWED.

TYPICAL SIZE OF LOOP DETECTORS ARE 6' × 6' AND 6' × 10'. REFER TO INTERSECTION LAYOUT FOR SPECIFIC LOOP DETECTORS TO BE PLACED.

ALL LOOP DETECTORS SHALL HAVE 4 TURNS OF CONDUCTORS.

THE LOOP DETECTOR ROADWAY CONDUCTORS AND THE LOOP DETECTOR LEAD-IN CABLE CONDUCTORS SHALL BE PROPERLY PREPARED AND CLEANED BEFORE SPLICING.

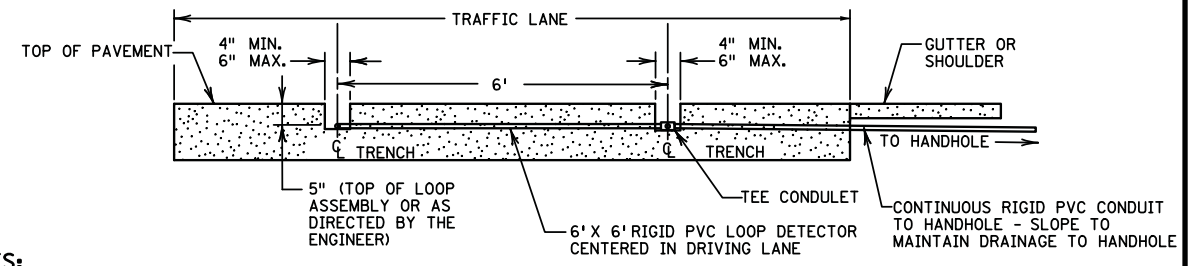
PRIOR TO FURNISHING AND INSTALLING THE APPROVED SPLICE KIT, THE CONTRACTOR SHALL SOLDER THE ENDS OF THE LOOP DETECTOR AND LEAD-IN CONDUCTOR, AND SHALL FURNISH AND INSTALL AN APPROPRIATE SIZED WIRE NUT TO THE SOLDERED ENDS PRIOR TO THE INSTALLATION OF THE SPLICE KITS.

LOOP DETECTORS SHALL BE SPLICED USING A MNDOT APPROVED SPLICE KIT AS LISTED ON THE MNDOT APPROVED PRODUCTS LIST (APL). MNDOT APPROVED SPLICE KITS SHALL BE FURNISHED AND INSTALLED, EITHER ACCORDING TO MANUFACTURERS INSTRUCTIONS OR BY AN ALTERNATIVE METHOD APPROVED BY THE ENGINEER.

SPLICE KITS SHALL BE FURNISHED AND INSTALLED IN HANDHOLES IN SUCH A MANNER AS TO ENSURE THAT EACH SPLICE KIT IS SUSPENDED AND/OR SECURED NEAR THE TOP OF THE HANDHOLE TO THE SATISFACTION OF THE ENGINEER. (PLACING SPLICE KITS ON TOP OF THE ELECTRICAL CABLES AND CONDUCTORS IS NOT ACCEPTABLE).

APPROVED DECEMBER 20, 2011 STATE DESIGN ENGINEER	STATE OF MINNESOTA DEPARTMENT OF TRANSPORTATION PREFORMED RIGID PVC CONDUIT LOOP DETECTOR LAYOUT NOTES	SPECIFICATION REFERENCE 2357 2360 2565	STANDARD PLATE NO. 8132B 2 OF 3

EXISTING PAVEMENT



NOTES:

USE THE LOOP DETECTOR TO BE PLACED FOR THE PURPOSE OF MARKING THE PAVEMENT LOCATION FOR THE MILLING OPERATION.

TO ACHIEVE FULL TRENCH DEPTH FOR CONDUIT PLACEMENT, MILL BEYOND THE DESIRED PAVEMENT MARKING.

PROVIDE A MINIMUM 5" CLEARANCE, MEASURED FROM THE TOP OF THE FINISHED PAVEMENT TO HIGHEST POINT OF LOOP ASSEMBLY (INCLUDING CONDUIT).

AN AIR COMPRESSOR UNIT (50 HP) IS REQUIRED FOR REMOVING ALL LOOSE MATERIAL FROM TRENCH PRIOR TO TACK COAT APPLICATION.

APPLY A TACK COAT AT A UNIFORM RATE TO THE BOTTOM AND EDGES OF THE MILLED AREA. USE AN EMULSIFIED ASPHALT PER SPEC. 2357.2A.

MIXTURE USED TO FILL THE RETROFIT LOOP DETECTOR TRENCHES SHALL MEET THE REQUIREMENTS OF MN/DOT SPECIFICATION 2360. AGGREGATE SIZE A OR B WILL BE ALLOWED WHEN 2360 IS UTILIZED. OTHER WEARING COURSE MIXTURE TYPES ARE ALLOWED WHEN APPROVED BY THE ENGINEER.

COMPACTION SHALL BE OBTAINED BY THE ORDINARY COMPACTION METHOD. BACKFILL THE TRENCH WITH A MINIMUM OF TWO LIFTS AND COMPACT EACH LIFT. BEFORE COMPACTING THE FIRST LIFT ENSURE THAT THERE IS ADEQUATE MIXTURE ON EACH SIDE AND ABOVE THE CONDUIT SO THAT THE CONDUIT IS NOT DAMAGED DURING COMPACTION OPERATIONS.

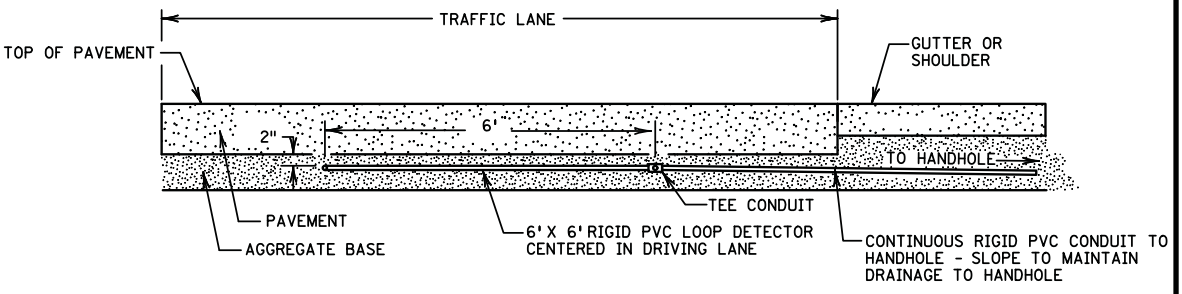
THE COMPACTED MIXTURE IN THE TRENCH SHOULD BE LEFT 1/4" TO 1/2" ABOVE THE ADJACENT PAVEMENT SURFACE TO PROVIDE FOR ADDITIONAL COMPACTION BY TRAFFIC.

WHEN LOOP DETECTORS ARE MILLED INTO CONCRETE SURFACES, REMOVE RUBBLE, SANDBLAST AND AIR BLAST THE TRENCH TO REMOVE DEBRIS. FILL THE TRENCH WITH AN APPROVED MATERIAL LISTED ON THE MNDOT CONCRETE UNIT'S WEB SITE FOR: "PACKAGED DRY RAPID HARDENING CEMENTITIOUS MATERIALS FOR CONCRETE REPAIRS".

MILLING IS REQUIRED FOR ALL RIGID PVC LOOP INSTALLATIONS. WHEN LOOPS ARE MILLED INTO EXISTING MILLED SURFACE THAT WILL BE OVERLAYED WITH BITUMINOUS, THE MINIMUM TRENCH DEPTH SHALL BE NO LESS THAN THE HIGHEST LOOP ASSEMBLY IN THE TRENCH.

WHEN MILLING INTO EXISTING BITUMINOUS SURFACE, BE ADVISED THAT CONCRETE MAY BE ENCOUNTERED UNDER THE BITUMINOUS SURFACE.

NEW PAVEMENT

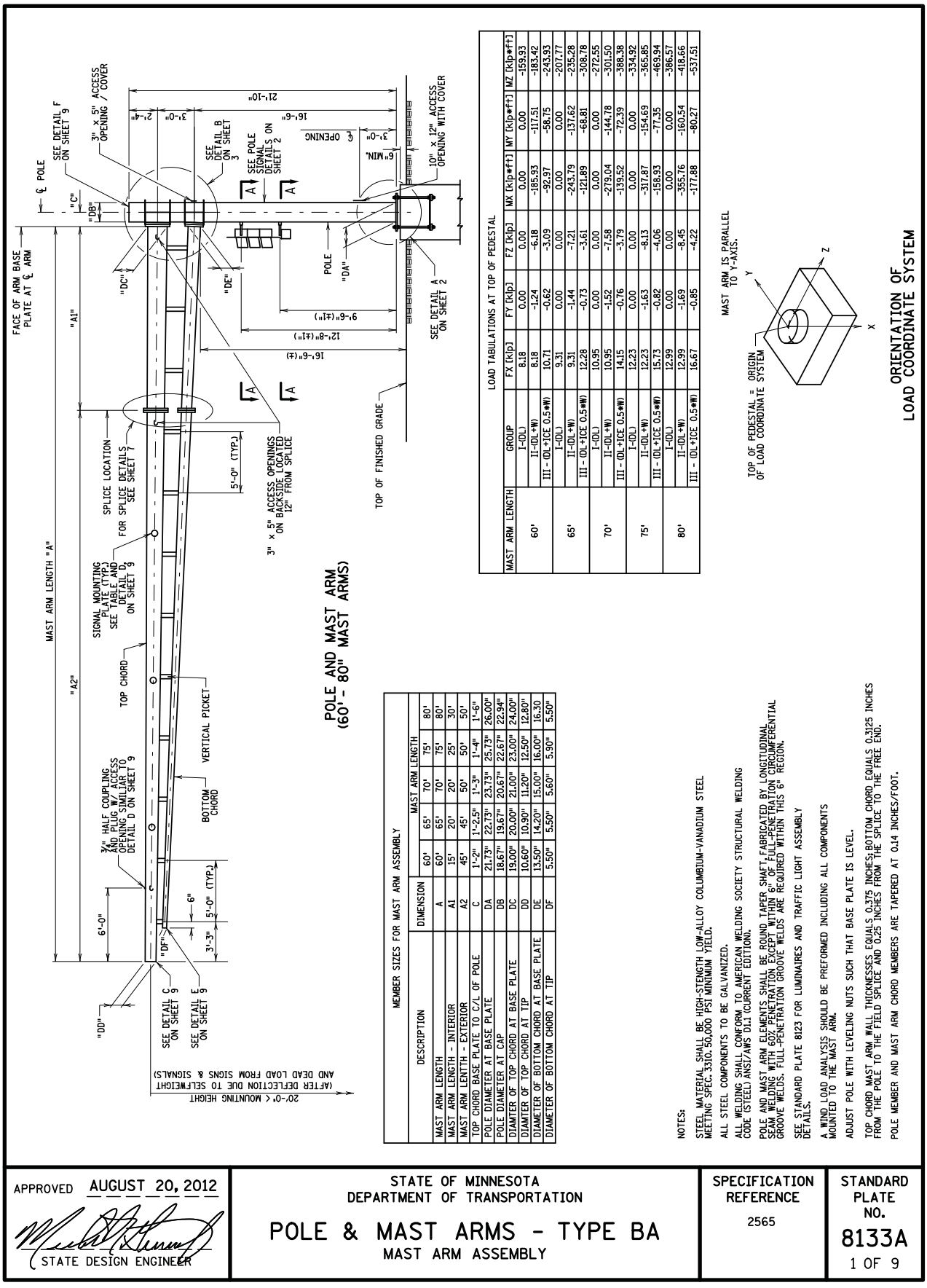


NOTES:

OBTAIN THE REQUIRED COMPACTION OF THE AGGREGATE BASE AFTER PLACEMENT OF LOOP DETECTOR AND LEAD-IN CONDUIT.

THE DEPTH OF THE LOOP MEASURED FROM THE TOP OF THE AGGREGATE BASE TO THE TOP OF THE CONDUIT SHALL NOT EXCEED 2".

APPROVED DECEMBER 20, 2011 STATE DESIGN ENGINEER	STATE OF MINNESOTA DEPARTMENT OF TRANSPORTATION PREFORMED RIGID PVC CONDUIT LOOP DETECTOR TYPICAL INSTALLATION	SPECIFICATION REFERENCE 2357 2360 2565	STANDARD PLATE NO. 8132B 3 OF 3



MEMBER SIZES FOR MAST ARM ASSEMBLY

DESCRIPTION	DIMENSION	MAST ARM LENGTH				
		60'	65'	70'	75'	80'
MAST ARM LENGTH	A	60'	65'	70'	75'	80'
MAST ARM LENGTH - INTERIOR	A1	15'	20'	20'	25'	30'
MAST ARM LENGTH - EXTERIOR	A2	45'	45'	50'	50'	50'
TOP CHORD BASE PLATE TO C/L OF POLE	C	1'-2"	1'-2.5"	1'-3"	1'-4"	1'-6"
POLE DIAMETER AT BASE PLATE	DA	21.73"	22.73"	23.73"	25.73"	26.00"
POLE DIAMETER AT CAP	DB	18.67"	19.67"	20.67"	22.67"	22.94"
DIAMTER OF TOP CHORD AT BASE PLATE	DC	19.00"	20.00"	21.00"	23.00"	24.00"
DIAMTER OF TOP CHORD AT TIP	DD	10.60"	10.90"	11.20"	12.50"	12.80"
DIAMETER OF BOTTOM CHORD AT BASE PLATE	DE	13.50"	14.20"	15.00"	16.00"	16.30
DIAMETER OF BOTTOM CHORD AT TIP	DF	5.50"	5.50"	5.60"	5.90"	5.50"

LOAD TABULATIONS AT TOP OF PEDESTAL

MAST ARM LENGTH	GROUP	FX (kip)	FY (kip)	FZ (kip)	MX (kip*ft)	MY (kip*ft)	MZ (kip*ft)
60'	I-(DL)	8.18	0.00	0.00	0.00	0.00	-159.93
	II-(DL+W)	8.18	-1.24	-6.18	-185.93	-117.51	-183.42
	III - (DL+ICE 0.5*W)	10.71	-0.62	-3.09	-92.97	-58.75	-243.93
65'	I-(DL)	9.31	0.00	0.00	0.00	0.00	-207.77
	II-(DL+W)	9.31	-1.44	-7.21	-243.79	-137.62	-235.28
	III - (DL+ICE 0.5*W)	12.28	-0.73	-3.61	-121.89	-68.81	-308.78
70'	I-(DL)	10.95	0.00	0.00	0.00	0.00	-272.55
	II-(DL+W)	10.95	-1.52	-7.58	-279.04	-144.78	-301.50
	III - (DL+ICE 0.5*W)	14.15	-0.76	-3.79	-139.52	-72.39	-388.38
75'	I-(DL)	12.23	0.00	0.00	0.00	0.00	-334.92
	II-(DL+W)	12.23	-1.63	-8.13	-317.87	-154.69	-365.85
	III - (DL+ICE 0.5*W)	15.73	-0.82	-4.06	-158.93	-77.35	-469.94
80'	I-(DL)	12.99	0.00	0.00	0.00	0.00	-386.57
	II-(DL+W)	12.99	-1.69	-8.45	-355.76	-160.54	-418.66
	III - (DL+ICE 0.5*W)	16.67	-0.85	-4.22	-177.88	-80.27	-537.51

ORIENTATION OF
LOAD COORDINATE SYSTEM

NOTES:

STEEL MATERIAL SHALL BE HIGH-STENGTH LOW-ALLOY COLUMBIUM-VANADIUM STEEL MEETING SPEC. 3310, 50,000 PSI MINIMUM YIELD.

ALL STEEL COMPONENTS TO BE GALVANIZED.

ALL WELDING SHALL CONFORM TO AMERICAN WELDING SOCIETY STRUCTURAL WELDING CODE (STEEL) ANSI/AWS D1.1 CURRENT EDITION.

POLE AND MAST ARM ELEMENTS SHALL BE ROUND TAPER SHAFT, FABRICATED BY LONGITUDINAL SEAM WELDING WITH 60% PENETRATION EXCEPT WITHIN 6" OF FULL-PENETRATION CIRCUMFERENTIAL GROOVE WELDS. FULL-PENETRATION GROOVE WELDS ARE REQUIRED WITHIN THIS 6" REGION.

SEE STANDARD PLATE 8123 FOR LUMINAIRES AND TRAFFIC LIGHT ASSEMBLY DETAILS.

A WIND LOAD ANALYSIS SHOULD BE PREFORMED INCLUDING ALL COMPONENTS MOUNTED TO THE MAST ARM.

ADJUST POLE WITH LEVELING NUTS SUCH THAT BASE PLATE IS LEVEL.

TOP CHORD MAST ARM WALL THICKNESSES EQUALS 0.375 INCHES, BOTTOM CHORD EQUALS 0.3125 INCHES FROM THE POLE TO THE FIELD SPLICE AND 0.25 INCHES FROM THE SPLICE TO THE FREE END.

POLE MEMBER AND MAST ARM CHORD MEMBERS ARE TAPERED AT 0.14 INCHES/FOOT.

APPROVED AUGUST 20, 2012

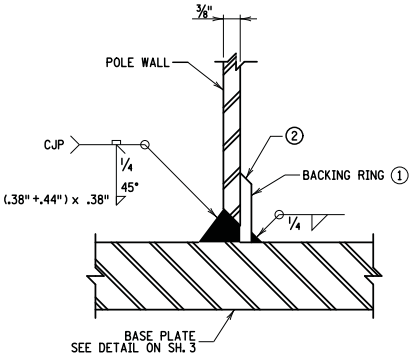
STATE DESIGN ENGINEER

STATE OF MINNESOTA
DEPARTMENT OF TRANSPORTATION

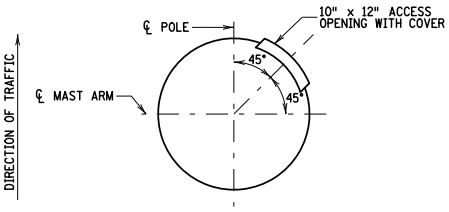
POLE & MAST ARMS - TYPE BA
MAST ARM ASSEMBLY

SPECIFICATION REFERENCE
2565

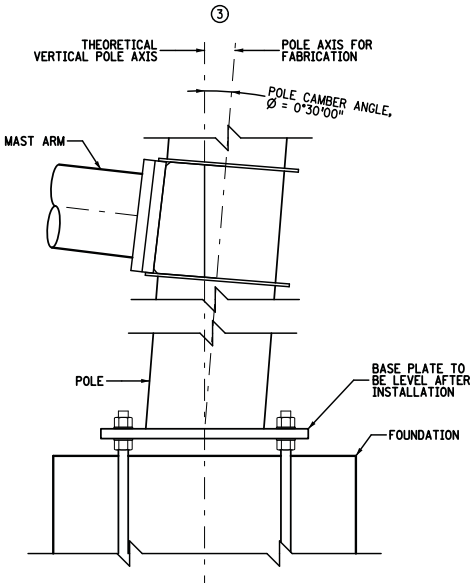
STANDARD PLATE NO.
8133A
1 OF 9



POLE TO BASE PLATE CONNECTION



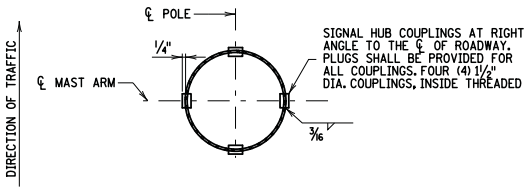
10" x 12" ACCESS OPENING



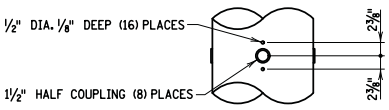
SCHEMATIC OF POLE ALIGNMENT

(NOT TO SCALE)

DETAIL A
POLE BASE DETAILS



SECTION A-A



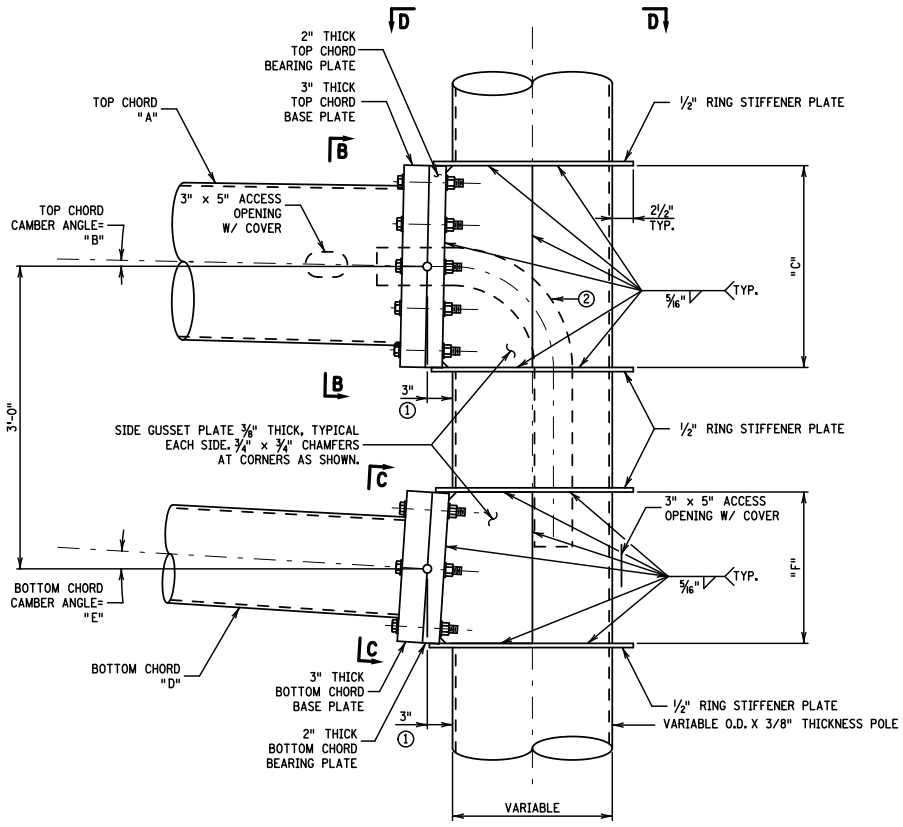
SIGNAL HUB DETAILS

POLE SIGNAL DETAILS

NOTES:

1. BACKING RING MAXIMUM THICKNESS = 3/8"
2. FIELD APPLIED 100 PERCENT SILICONE CAULK (EXTERIOR USAGE) AT TOP OF BACKING RING ALONG ENTIRE CIRCUMFERENCE
3. POLE ROTATION IS ABOUT A HORIZONTAL AXIS ORIENTED PERPENDICULAR TO MAST ARM AXIS. SENSE OF ROTATION IS SUCH THAT TIP OF MAST ARM WILL BE RAISED.

APPROVED AUGUST 20, 2012 STATE DESIGN ENGINEER	STATE OF MINNESOTA DEPARTMENT OF TRANSPORTATION POLE & MAST ARMS - TYPE BA POLE DETAILS	SPECIFICATION REFERENCE 2565	STANDARD PLATE NO. 8133A 2 OF 9



DETAIL B
MAST ARM CONNECTION DETAILS

MAST ARM CONNECTIONS DIMENSIONS						
DESCRIPTION	DIMENSION	MAST ARM LENGTH				
		60'	65'	70'	75'	80'
TOP CHORD DIAMETER	A	19" O.D. TO 10.6" O.D.	20" O.D. TO 10.9" O.D.	21" O.D. TO 11.2" O.D.	23" O.D. TO 12.5" O.D.	24" O.D. TO 12.8" O.D."
TOP CHORD CAMBER ANGLE	B	1° 00' 00"	1° 00' 00"	1° 00' 00"	1° 00' 00"	1° 00' 00"
HEIGHT OF TOP PLATE	C	2'-0"	2'-2"	2'-2"	2'-5"	2'-10"
BOTTOM CHORD DIAMETER	D	13.5" O.D. TO 5.5" O.D.	14.2" O.D. TO 5.5" O.D.	15" O.D. TO 5.6" O.D.	16" O.D. TO 5.9" O.D.	16.3" O.D. TO 5.5" O.D.
BOTTOM CHORD CAMBER ANGLE	E	3° 30' 00"	3° 30' 00"	3° 00' 00"	3° 00' 00"	2° 30' 00"
HEIGHT OF BOTTOM PLATE	F	1'-6"	1'-7"	1'-8"	1'-10"	2'-2"

NOTES:

ALL BOLTS AND NUTS SHALL MEET ASTM A 325 TYPE 1. ALL WASHERS SHALL MEET ASTM F 436.

EACH MAST ARM CONNECTION CONSISTS OF A BUILT-UP BOX WELDED TO THE POLE. THE MAST ARM CHORD MEMBER IN TURN IS CONNECTED BY A BOLTED CONNECTION.

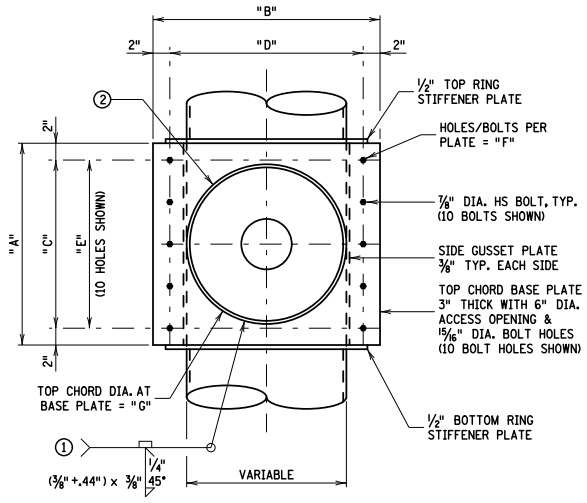
EACH BUILT-UP BOX CONSISTS OF:
2 - HORIZONTAL RING STIFFENER PLATES, 0.50" THICK,
2 - VERTICAL SIDE GUSSET PLATES, 0.375" THICK, AND
1 - BEARING PLATE, 2" THICK AND ALIGNED FOR PROPER CAMBER ANGLE.

MAST ARM CHORD MEMBERS ARE WELDED TO A 3" THICK CHORD BASE PLATE, WHICH IS BOLTED TO THE BEARING PLATE OF THE BUILT-UP BOX BY A SPECIFIED NUMBER OF BOLTS.

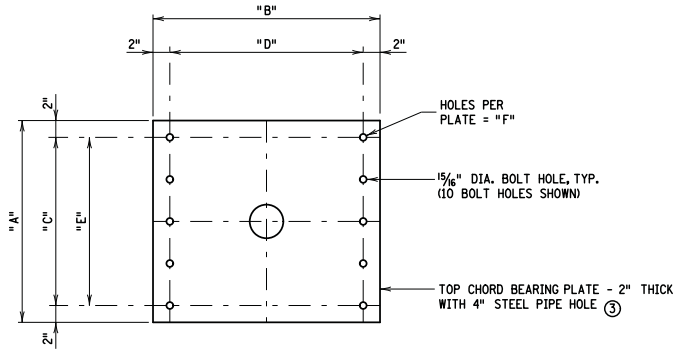
① DISTANCE TO MAST ARM REFERENCE POINT. THE REFERENCE POINT LOCATED ON THE AXIS OF THE RESPECTIVE MAST ARM CHORD MEMBER WHERE IT INTERSECTS THE INCLINED PLANE DEFINED BY THE CONTACT AREA BETWEEN THE BEARING PLATE AND THE BASE PLATE.

② 4" SCH. 40 STEEL PIPE CABLE GUIDE WITH 1'-9" TANGENT AT EXPOSED END, BENDING INTO A 90° BEND (12" RAD.). CABLE GUIDE PROJECTS 6" BEYOND TOP CHORD BEARING PLATE AND HAS 3/16" FILLET WELD ALL AROUND. BREAK ALL EDGES OF GUIDE.

APPROVED AUGUST 20, 2012 STATE DESIGN ENGINEER	STATE OF MINNESOTA DEPARTMENT OF TRANSPORTATION POLE & MAST ARMS - TYPE BA MAST ARM CONNECTION DETAILS	SPECIFICATION REFERENCE 2565	STANDARD PLATE NO. 8133A 3 OF 9



SECTION B-B
TOP CHORD BASE PLATE
(FOR 60' MAST ARM SHOWN)



TOP CHORD BEARING PLATE
(FOR 60' MAST ARM SHOWN)

TOP CHORD BEARING AND BASE PLATE DIMENSIONS						
DESCRIPTION	DIMENSION	MAST ARM LENGTH				
		60'	65'	70'	75'	80'
PLATE HEIGHT	A	2'-0"	2'-2"	2'-2"	2'-5"	2'-10"
PLATE WIDTH	B	2'-3"	2'-4"	2'-5"	2'-7"	2'-8"
TOTAL HOLE SPACING VERTICAL	C	1'-8"	1'-10"	1'-10"	2'-0 3/4"	2'-6"
TOTAL HOLE SPACING HORIZONTAL	D	1'-11"	2'-0"	2'-1"	2'-3"	2'-4"
HOLE SPACING	E	4 SPACES @ 5"	4 SPACES @ 5-1/2"	4 SPACES @ 5-1/2"	6 SPACES @ 4-1/8"	6 SPACES @ 5"
HOLES PER PLATE	F	10	10	10	14	14
TOP CHORD O.D. AT BASE PLATE	G	19" O.D.	20" O.D.	21" O.D.	23" O.D.	24" O.D.

NOTES:

ALL BOLTS AND NUTS SHALL MEET ASTM A 325 TYPE 1. ALL WASHERS SHALL MEET ASTM F 436.

1. MAXIMUM BACKING RING THICKNESS = 3/8"
2. FIELD APPLY 100% SILICONE CAULK (EXTERIOR USAGE) AT TOP OF BACKING RING ALONG ENTIRE INTERIOR CIRCUMFERENCE OF ARM. SEE POLE TO BASE PLATE CONNECTION DETAIL FOR ADDITIONAL INFORMATION.
3. 4" SCH. 40 STEEL PIPE CABLE GUIDE WITH 1'-9" TANGENT AT EXPOSED END, BENDING INTO A 90° BEND (12" RAD.). CABLE GUIDE PROJECTS 6" BEYOND TOP CHORD BEARING PLATE AND HAS 3/16" FILLET WELD ALL AROUND. BREAK ALL EDGES OF GUIDE.

APPROVED AUGUST 20, 2012
STATE DESIGN ENGINEER

STATE OF MINNESOTA
DEPARTMENT OF TRANSPORTATION

POLE & MAST ARMS - TYPE BA
TOP CHORD CONNECTION DETAILS

SPECIFICATION REFERENCE
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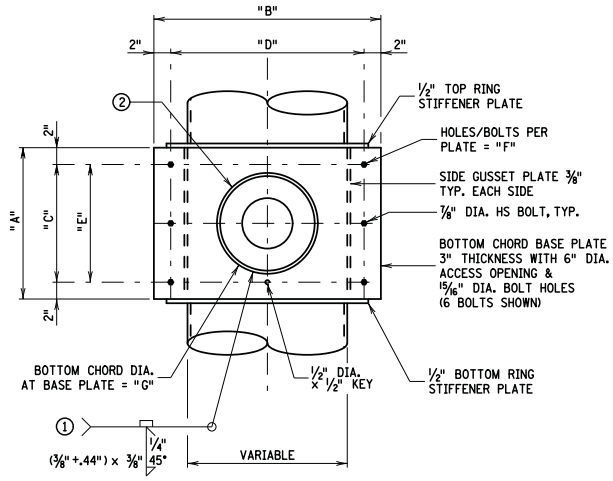
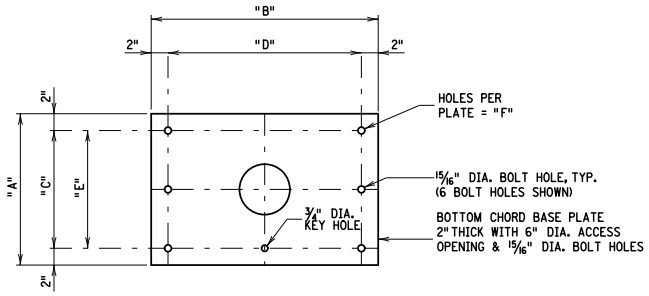


SECTION C-C
BOTTOM CHORD BASE PLATE
(FOR 60' MAST ARM SHOWN)



BOTTOM CHORD BEARING PLATE
(FOR 60' MAST ARM SHOWN)

BOTTOM CHORD BEARING AND BASE PLATE DIMENSIONS						
DESCRIPTION	DIMENSION	MAST ARM LENGTH				
		60'	65'	70'	75'	80'
PLATE HEIGHT	A	1'-6"	1'-7"	1'-8"	1'-10"	2'-2"
PLATE WIDTH	B	2'-3"	2'-4"	2'-5"	2'-7"	2'-8"
TOTAL HOLE SPACING VERTICAL	C	1'-2"	1'-3"	1'-4"	1'-6"	1'-10"
TOTAL HOLE SPACING HORIZONTAL	D	1'-11"	2'-0"	2'-1"	2'-3"	2'-4"
HOLE SPACING	E	2 SPACES @ 7"	2 SPACES @ 7-1/2"	2 SPACES @ 8"	3 SPACES @ 6"	4 SPACES @ 5-1/2"
HOLES PER PLATE	F	6	6	6	8	10
BOTTOM CHORD O.D. AT BASE PLATE	G	12" O.D.	13" O.D.	15" O.D.	16" O.D.	16" O.D.

NOTES:

ALL BOLTS AND NUTS SHALL MEET ASTM A 325 TYPE 1. ALL WASHERS SHALL MEET ASTM F 436.

1. MAXIMUM BACKING RING THICKNESS = ⅜"
2. FIELD APPLY 100% SILICONE CAULK (EXTERIOR USAGE) AT TOP OF BACKING RING ALONG ENTIRE INTERIOR CIRCUMFERENCE OF ARM. SEE POLE TO BASE PLATE CONNECTION DETAIL FOR ADDITIONAL INFORMATION.

APPROVED AUGUST 20, 2012
STATE DESIGN ENGINEER

STATE OF MINNESOTA
DEPARTMENT OF TRANSPORTATION

POLE & MAST ARMS - TYPE BA
BOTTOM CHORD CONNECTION DETAILS

SPECIFICATION REFERENCE
2565

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8133A
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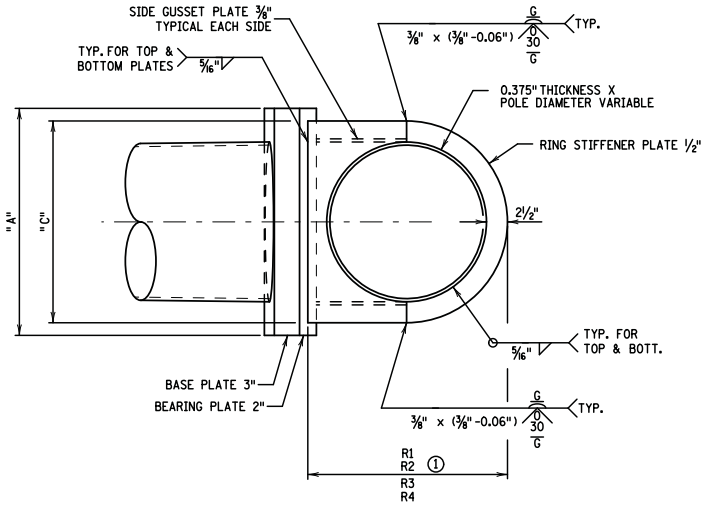
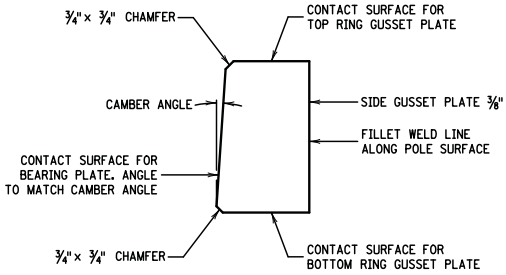


SECTION D-D
STIFFENER PLATE DETAIL



SIDE GUSSET PLATE DETAIL

MAST ARM CONNECTION						
DESCRIPTION	DIMENSION	MAST ARM LENGTH				
		60'	65'	70'	75'	80'
PLATE WIDTH	A	2'-3"	2'-4"	2'-5"	2'-7"	2'-8"
RING STIFFENER PLATE WIDTH	C	2'-0"	2'-1"	2'-2"	2'-4"	2'-5"
TOP CHORD - TOP RING STIFFENER PLATE	R1	23-1/2"	24-1/2"	25"	27"	28-1/2"
TOP CHORD - BOTTOM RING STIFFENER PLATE	R2	23-3/4"	24-1/2"	25-1/4"	24-1/4"	28-3/4"
BOTTOM CHORD - TOP RING STIFFENER PLATE	R3	24"	25"	25-1/2"	27-1/2"	29"
BOTTOM CHORD - BOTTOM RING STIFFENER PLATE	R4	24-1/2"	25-1/4"	25-3/4"	27-3/4"	29-1/4"

NOTES:

(1) ALL RING STIFFENER PLATES ARE IDENTICAL EXCEPT FOR THIS DIMENSION, WHICH DEPENDS ON THE PLATE LOCATION AND THE CAMBER ANGLE OF THE MAST ARM CHORD MEMBER.

APPROVED AUGUST 20, 2012

STATE DESIGN ENGINEER

STATE OF MINNESOTA
DEPARTMENT OF TRANSPORTATION

POLE & MAST ARMS - TYPE BA
STIFFENER PLATE/GUSSET PLATE CONNECTION DETAILS

SPECIFICATION REFERENCE
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STANDARD PLATE NO.
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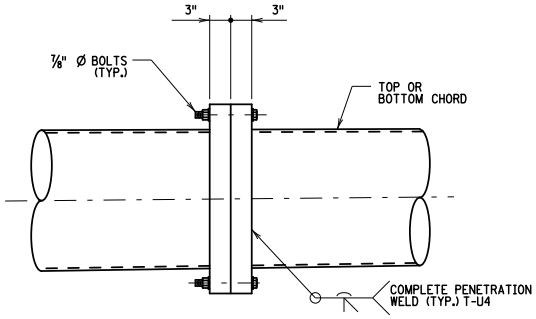
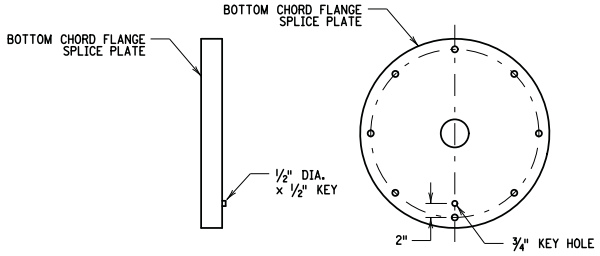
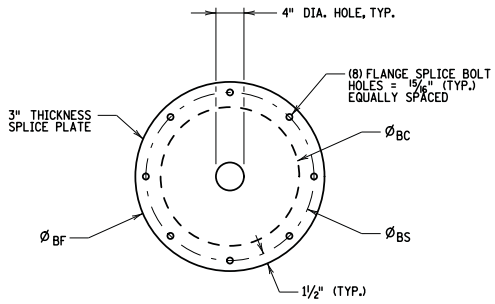
FLANGE SPLICE PLATE							
		TOP CHORD			BOTTOM CHORD		
POLE TYPE	MAST ARM LENGTH	FLANGE SPLICE PLATE DIAMETER Ø TF	BOLT CIRCLE DIAMETER Ø TS	CHORD DIAMETER @ SPLICE Ø TC	FLANGE SPLICE PLATE DIAMETER Ø BF	BOLT CIRCLE DIAMETER Ø BS	CHORD DIAMETER @ SPLICE Ø BC
BA60	60'-0"	24"	21"	16.9"	17"	14"	9.9"
BA65	65'-0"	24.5"	21.5"	17.2"	18"	15"	11.4"
BA70	70'-0"	25.5"	22.5"	18.2"	19.5"	16.5"	12.2"
BA75	75'-0"	27"	24"	19.5"	19.5"	16.5"	12.5"
BA80	80'-0"	27"	24"	19.8"	19"	16"	12.1"



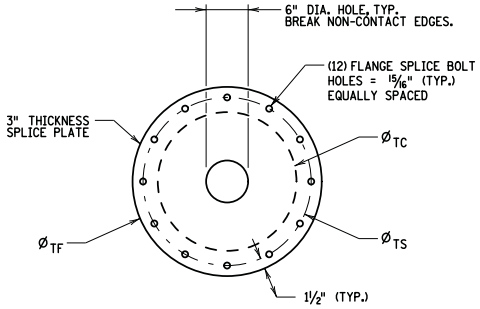
FLANGE SPLICE



SPLICE KEY



BOTTOM CHORD FLANGE SPLICE PLATE

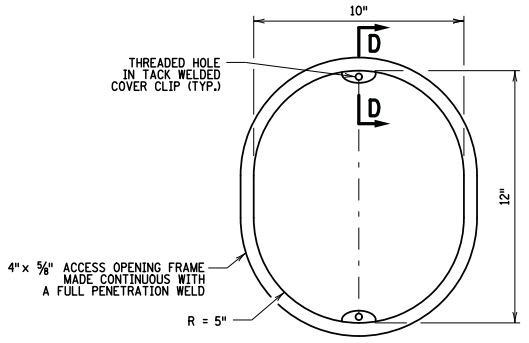


TOP CHORD FLANGE SPLICE PLATE

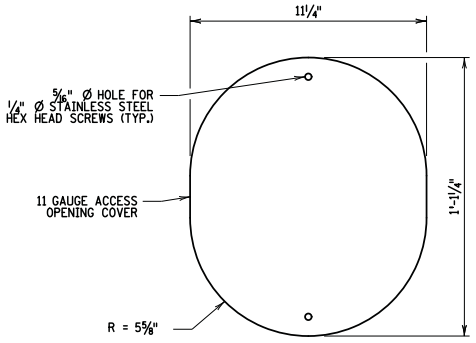
NOTE:

ALL BOLTS AND NUTS SHALL MEET ASTM A 325 TYPE 1.
ALL WASHERS SHALL MEET ASTM F 436.

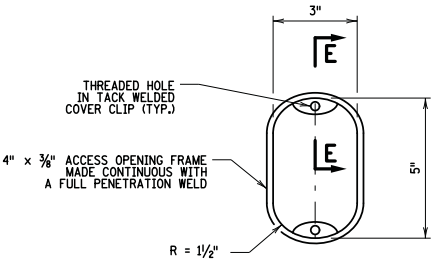
APPROVED AUGUST 20, 2012 STATE DESIGN ENGINEER	STATE OF MINNESOTA DEPARTMENT OF TRANSPORTATION POLE & MAST ARMS - TYPE BA FLANGE SPLICE DETAILS	SPECIFICATION REFERENCE 2565	STANDARD PLATE NO. 8133A 7 OF 9



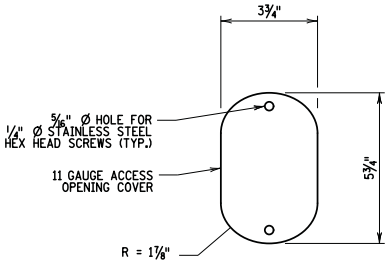
10" x 12" ACCESS OPENING FRAME



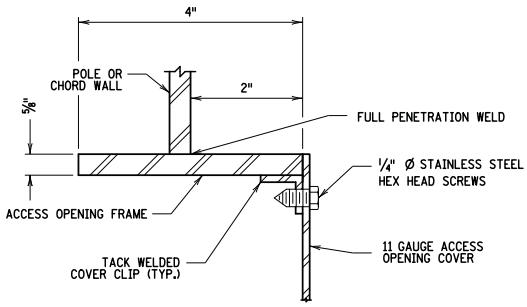
10" x 12" ACCESS OPENING COVER



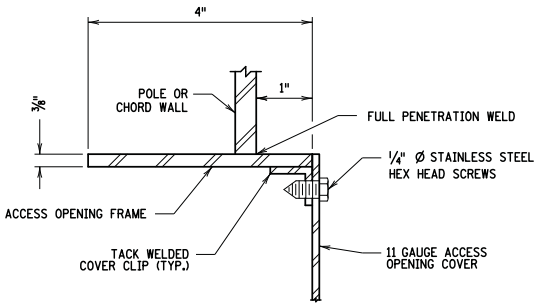
3" x 5" ACCESS OPENING FRAME



3" x 5" ACCESS OPENING COVER



SECTION D-D

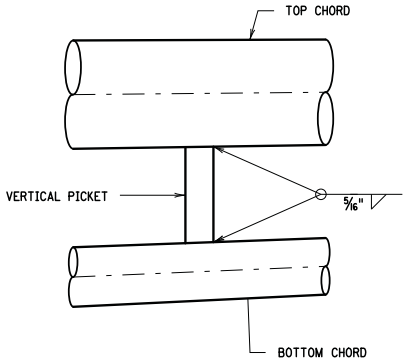


SECTION E-E

VERTICAL PICKET		
POLE TYPE	MAST ARM LENGTH	BAR DIMENSION
BA60	60'-0"	4" x 5/8"
BA65	65'-0"	4-1/2" x 5/8"
BA70	70'-0"	4-1/2" x 5/8"
BA75	75'-0"	5" x 5/8" ①
BA80	80'-0"	5" x 5/8" ①

NOTE:

① 6" x 5/8" BARS REQUIRED AT THE TWO PICKET LOCATIONS NEAREST TO THE POLE.



VERTICAL PICKET

APPROVED AUGUST 20, 2012

STATE DESIGN ENGINEER

STATE OF MINNESOTA
DEPARTMENT OF TRANSPORTATION

POLE & MAST ARMS - TYPE BA

ACCESS OPENING AND VERTICAL PICKET DETAILS

SPECIFICATION REFERENCE
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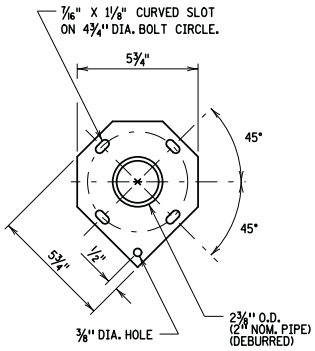
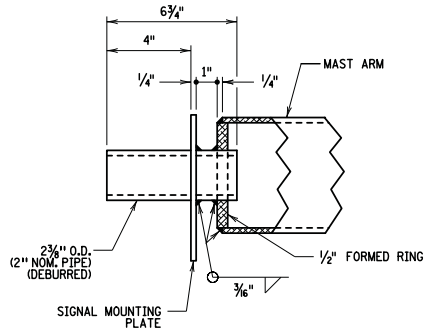
SIGNAL MOUNTING PLATE LOCATIONS		
MAST ARM LENGTH	NUMBER OF SIGNAL MOUNTING PLATES	DISTANCES FROM FACE OF ARM BASE PLATE AT ℄ ARM TO CENTER OF SIGNAL MOUNTING PLATE
60'-0"	4	25', 37', 49', & 60'
65'-0"	4	30', 42', 54', & 65'
70'-0"	5	23', 35', 47', 59', & 70'
75'-0"	5	28', 40', 52', 64', & 75'
80'-0"	5	33', 45', 57', 69', & 80'

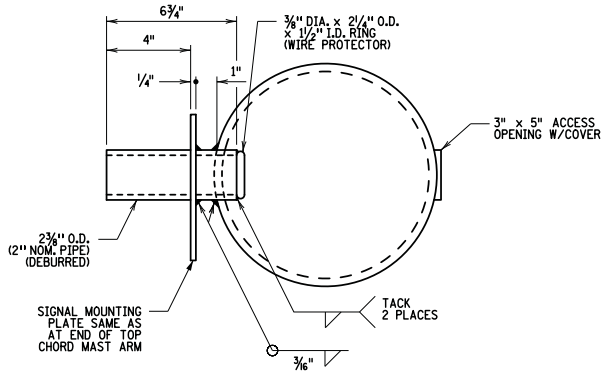


FRONT VIEW

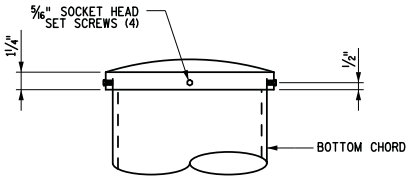


SIDE VIEW

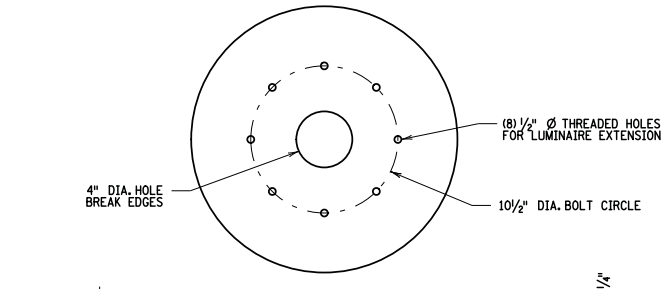
DETAIL C
SIGNAL MOUNTING PLATE
AT END OF TOP CHORD MAST ARM



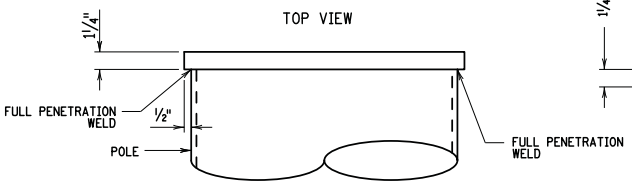
DETAIL D
SIGNAL MOUNTING PLATE
ON TOP CHORD MAST ARM



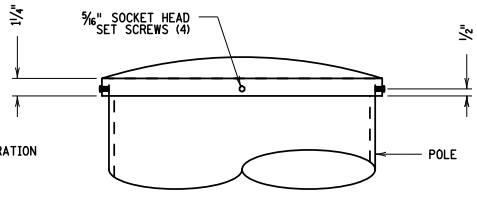
DETAIL E



TOP VIEW



POLE TOP WITH LUMINAIRE



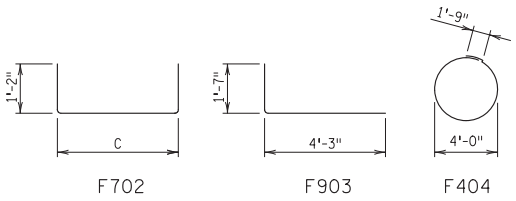
POLE TOP WITHOUT LUMINAIRE

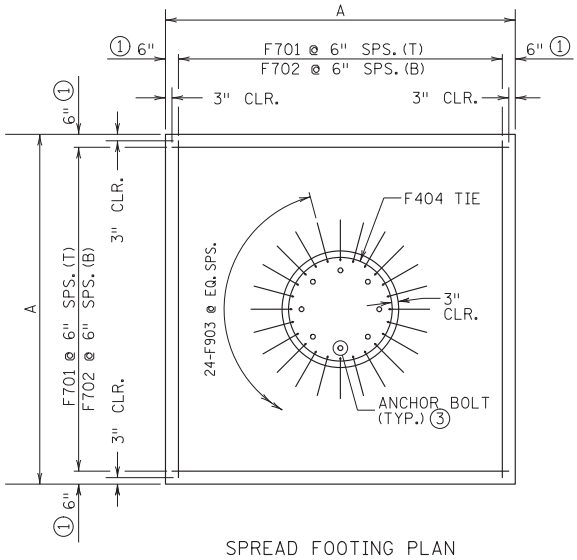
DETAIL F

APPROVED AUGUST 20, 2012 STATE DESIGN ENGINEER	STATE OF MINNESOTA DEPARTMENT OF TRANSPORTATION **POLE & MAST ARMS - TYPE BA** MISCELLANEOUS DETAILS	SPECIFICATION REFERENCE 2565	STANDARD PLATE NO. 8133A 9 OF 9

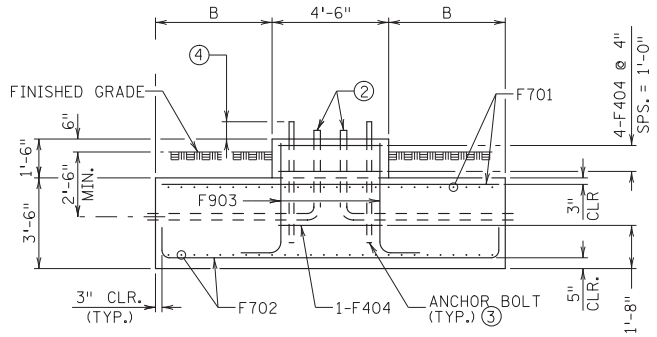
BILL OF REINFORCEMENT - SPREAD FOOTING												
BAR	MAST ARM LENGTH										SHAPE	LOCATION
	60'-0"		65'-0"		70'-0"		75'-0"		80'-0"			
	NO.	LENGTH	NO.	LENGTH	NO.	LENGTH	NO.	LENGTH	NO.	LENGTH		
F701	40	10'-0"	44	10'-9"	46	11'-3"	48	12'-0"	52	13'-0"	——	SPREAD FOOTING TOP
F702	40	12'-4"	44	13'-1"	46	13'-7"	48	14'-4"	52	15'-4"	⌊_⌋	SPREAD FOOTING BOTTOM
F903	24	5'-10"	24	5'-10"	24	5'-10"	24	5'-10"	24	5'-10"	⌊	PEDESTAL VERTICAL
F404	5	14'-4"	5	14'-4"	5	14'-4"	5	14'-4"	5	14'-4"	○	PEDESTAL TIE

SPREAD FOOTING FOUNDATION DATA					
POLE TYPE	MAST ARM LENGTH	SPREAD FOOTING DIMENSIONS			ANCHOR BOLT PROJECTION
		A	B	C	G
BA60	60'-0"	10'-6"	3'-0"	10'-0"	8"
BA65	65'-0"	11'-3"	3'-4 1/2"	10'-9"	9"
BA70	70'-0"	11'-9"	3'-7 1/2"	11'-3"	10"
BA75	75'-0"	12'-6"	4'-0"	12'-0"	10"
BA80	80'-0"	13'-6"	4'-6"	13'-0"	11"





SPREAD FOOTING PLAN



SPREAD FOOTING ELEVATION

NOTES:

ANCHOR BOLTS SHALL BE GALVANIZED IN ACCORDANCE WITH SPEC. 3392.

PREFORMED JOINT FILLER SHALL BE USED BETWEEN FOUNDATION AND SIDEWALK OR CONCRETE AREAS.

CONCRETE SHALL BE MIX 3G52 PER MnDOT SPECIFICATION 2461.

NO COLD CONCRETE CONSTRUCTION JOINTS WILL BE PERMITTED.

CONCRETE FOUNDATIONS SHALL CURE A MINIMUM OF SEVEN DAYS PRIOR TO PLACING POLE AND MAST ARM.

THE APPLICABILITY OF THE SOIL PARAMETERS LISTED ON THE FOUNDATION STANDARD SHEETS SHALL BE VERIFIED BY THE DATA OBTAINED FROM 1 (ONE) SOIL BORING AT THE LOCATION OF EACH MAST ARM FOUNDATION.

MnDOT DISTRICT SOILS ENGINEER SHALL APPROVE THE TYPE OF FOUNDATION TO USE.

SPREAD FOOTINGS HAVE BEEN DESIGNED BASED ON AN ALLOWABLE BEARING PRESSURE OF 2.50 ksf. ANY EXCEEDANCE REQUIRES AN APPROVAL BY THE DISTRICT SOILS ENGINEER.

REINFORCEMENT BARS FOR THE FOUNDATIONS SHALL BE DEFORMED BILLET BARS PER AASHTO M 31, GRADE 60 (MnDOT SPECIFICATIONS 2472 AND 3301).

① 6" FOR 60'-0", 65'-0", 75'-0" & 80'-0" MAST ARM LENGTHS. 4-½" FOR 70'-0" MAST ARM LENGTH.

② CONDUIT PER SPEC. 3801 OR 3803, SIZE AND NUMBER AS REQUIRED IN PLANS OR SPECIAL PROVISIONS. 24" MINIMUM PROJECTION ABOVE FOUNDATION. OPEN ENDS OF ALL CONDUIT INTO FOUNDATION SHALL BE POSITIONED TO FIT INSIDE THE 12" DIA. OPENING IN THE BASE PLATE AND CAPPED UNTIL CABLES ARE PLACED.

③ SEE ANCHOR BOLT ASSEMBLY DETAIL ON SHEET 3 OF 4.

④ FOR THREAD PROJECTION, SEE ANCHOR BOLT DETAIL ON SHEET 4 OF 4.

APPROVED JULY 15, 2015

STATE DESIGN ENGINEER

STATE OF MINNESOTA
DEPARTMENT OF TRANSPORTATION

POLE FOUNDATION - TYPE BA
SPREAD FOOTING FOUNDATION

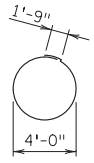
SPECIFICATION REFERENCE 2565

STANDARD PLATE NO. 8134C

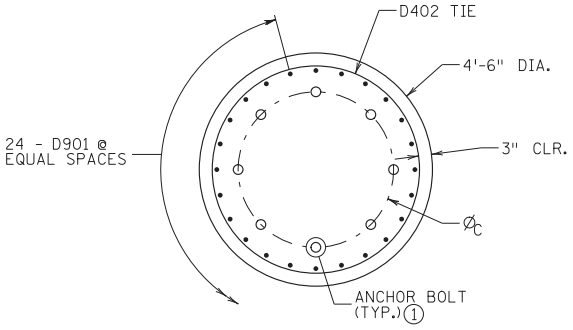
1 OF 4

BILL OF REINFORCEMENT - DRILLED SHAFT												
D901	24	E	24	E	24	E	24	E	24	E	———	DRILLED SHAFT VERTICAL
D402	33	14'-4"	39	14'-4"	41	14'-4"	43	14'-4"	47	14'-4"	○	DRILLED SHAFT TIE

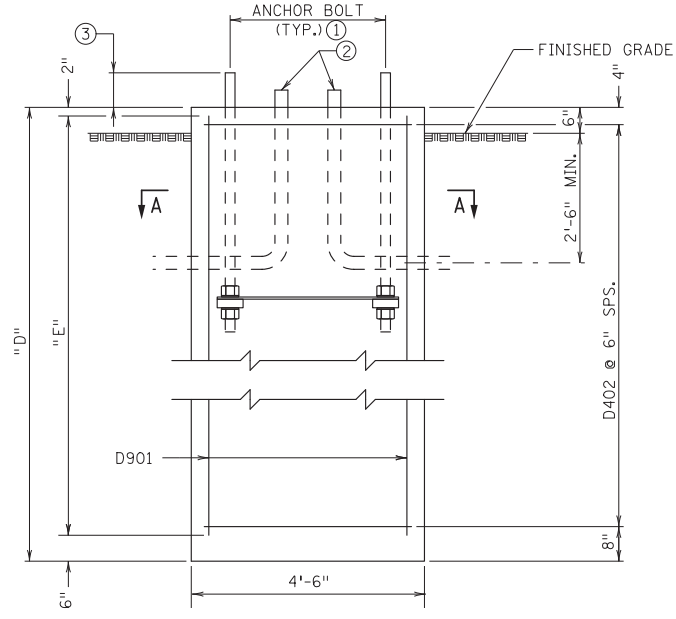
DRILLED SHAFT FOUNDATION DATA				
POLE TYPE	MAST ARM LENGTH	D	E	ANCHOR BOLT CIRCLE DIAMETER $\emptyset_C$
BA60	60'-0"	17'-0"	16'-4"	29"
BA65	65'-0"	20'-0"	19'-4"	29"
BA70	70'-0"	21'-0"	20'-4"	31"
BA75	75'-0"	22'-0"	21'-4"	33"
BA80	80'-0"	24'-0"	23'-4"	33"



D402



SECTION A-A



DRILLED SHAFT ELEVATION

NOTES:

ANCHOR BOLTS SHALL BE GALVANIZED IN ACCORDANCE WITH SPEC. 3392.

PREFORMED JOINT FILLER SHALL BE USED BETWEEN FOUNDATION AND SIDEWALK OR CONCRETE AREAS.

CONCRETE SHALL BE MIX 3G52 PER MnDOT SPECIFICATION 2461.

NO COLD CONCRETE CONSTRUCTION JOINTS WILL BE PERMITTED.

CONCRETE FOUNDATIONS SHALL CURE A MINIMUM OF SEVEN DAYS PRIOR TO PLACING POLE AND MAST ARM.

THE APPLICABILITY OF THE SOIL PARAMETERS LISTED ON THE FOUNDATION STANDARD SHEETS SHALL BE VERIFIED BY THE DATA OBTAINED FROM 1 (ONE) SOIL BORING AT THE LOCATION OF EACH MAST ARM FOUNDATION.

MnDOT DISTRICT SOILS ENGINEER SHALL APPROVE THE TYPE OF FOUNDATION TO USE.

A FIBER FORMING TUBE MAY ONLY BE USED FOR FORMING THE TOP FOUR (4) FEET OF THE DRILLED SHAFT FOUNDATION. THE DRILLED HOLE SHALL BE PROTECTED AGAINST COLLAPSING.

DRILLED SHAFTS HAVE BEEN DESIGNED BASED ON EITHER OF THE FOLLOWING SOIL PARAMETERS. ANY VARIATION REQUIRES AN APPROVAL BY THE SOILS ENGINEER:

COHESIVE SOILS:

C = 1.0 ksf	SHEAR STRENGTH
γ_s = 0.125 kcf	UNIT WEIGHT OF SOIL

GRANULAR SOILS:

$\emptyset$ = 32°	ANGLE OF FRICTION
γ_s = 0.125 kcf	UNIT WEIGHT OF SOIL
K_o = 0.50	AT-REST COEFFICIENT
μ = 0.70	COEFFICIENT OF FRICTION

REINFORCEMENT BARS FOR THE FOUNDATIONS SHALL BE DEFORMED BILLET BARS PER AASHTO M 31, GRADE 60 (MnDOT SPECIFICATIONS 2472 AND 3301).

(1) SEE ANCHOR BOLT ASSEMBLY DETAIL ON SHEET 3.

(2) CONDUIT PER SPEC. 3801 OR 3803, SIZE AND NUMBER AS REQUIRED IN PLANS OR SPECIAL PROVISIONS. 24" MINIMUM PROJECTION ABOVE FOUNDATION. OPEN ENDS OF ALL CONDUIT INTO FOUNDATION SHALL BE POSITIONED TO FIT INSIDE THE 12" DIA. OPENING IN THE BASE PLATE AND CAPPED UNTIL CABLES ARE PLACED.

(3) FOR THREAD PROJECTION, SEE ANCHOR BOLT DETAIL ON SHEET 4.

APPROVED JULY 15, 2015

STATE DESIGN ENGINEER

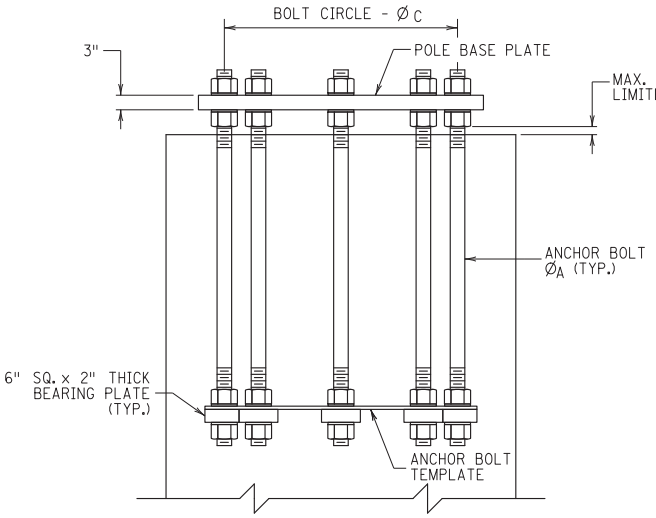
STATE OF MINNESOTA
DEPARTMENT OF TRANSPORTATION

POLE FOUNDATION - TYPE BA
DRILLED SHAFT FOUNDATION

SPECIFICATION REFERENCE 2565

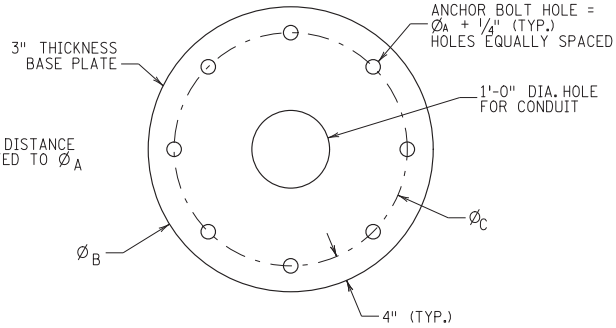
STANDARD PLATE NO. 8134C

2 OF 4

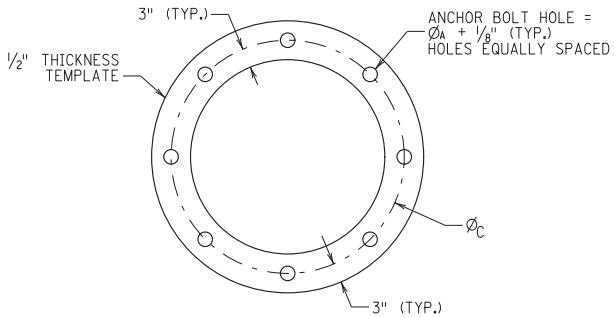


PARTIAL ELEVATION

(SHOWING BASE PLATE & ANCHOR BOLT ASSEMBLY)

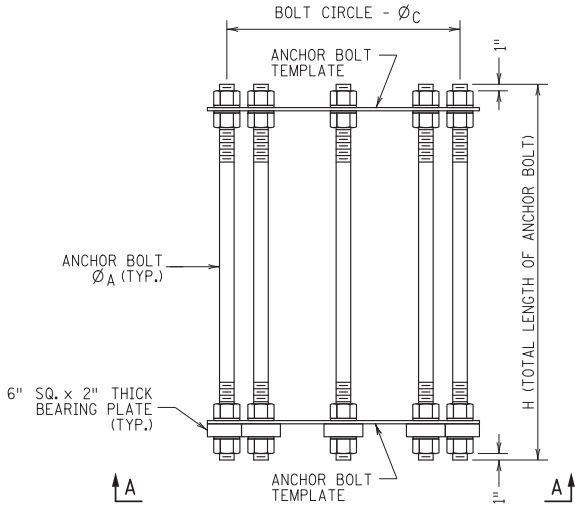


BASE PLATE OF MAST ARM POLE

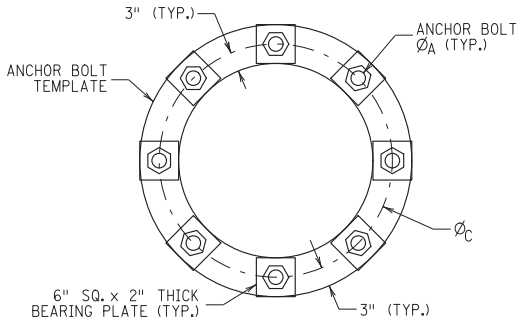


ANCHOR BOLT TEMPLATE

(2 PER ASSEMBLY)



ANCHOR BOLT ASSEMBLY



VIEW A-A

POLE TYPE	MAST ARM LENGTH	BASE PLATE	ANCHOR BOLT		
		DIAMETER Ø B	ANCHOR BOLT DIAMETER Ø A	BOLT CIRCLE DIAMETER Ø C	TOTAL LENGTH H
BA60	60'-0"	37"	1.50"	29"	42"
BA65	65'-0"	37"	1.75"	29"	47"
BA70	70'-0"	39"	2.00"	31"	52"
BA75	75'-0"	41"	2.00"	33"	52"
BA80	80'-0"	41"	2.25"	33"	59"

NOTES:

ALL EXPOSED HEX NUTS AND WASHERS SHALL BE GALVANIZED PER MNDOT SPEC. 3392.

ANCHOR BOLTS SHALL BE GALVANIZED PER MNDOT SPEC. 3392 TO THE LIMITS SHOWN ON SHEET 4 OF 4.

ANCHOR BOLT TEMPLATES AND HARDWARE EMBEDDED IN CONCRETE SHALL NOT BE GALVANIZED.

ANCHOR BOLT MATERIAL SHALL MEET SPEC. 3385 TYPE C. EACH ANCHOR BOLT TO BE PROVIDED WITH 4 (FOUR) HEAVY HEX NUTS, 4 (FOUR) HARDENED FLAT WASHERS, AND 1 (ONE) BEARING PLATE.

APPROVED JULY 15, 2015

STATE DESIGN ENGINEER

STATE OF MINNESOTA
DEPARTMENT OF TRANSPORTATION

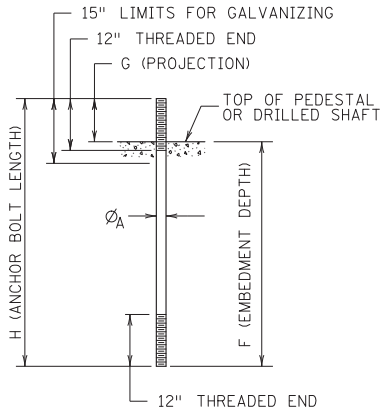
POLE FOUNDATION - TYPE BA

ANCHOR BOLT AND BASE PLATE DETAILS

SPECIFICATION REFERENCE 2565

STANDARD PLATE NO. 8134C

3 OF 4



ANCHOR BOLT DETAIL

POLE TYPE	MAST ARM LENGTH	ANCHOR BOLTS			
		EMBEDMENT DEPTH F	PROJECTION G	TOTAL LENGTH H	DIAMETER $Ø_A$
BA60	60'-0"	34"	8"	42"	1.50"
BA65	65'-0"	38"	9"	47"	1.75"
BA70	70'-0"	42"	10"	52"	2.00"
BA75	75'-0"	42"	10"	52"	2.00"
BA80	80'-0"	48"	11"	59"	2.25"

APPROVED JULY 15, 2015

STATE DESIGN ENGINEER

STATE OF MINNESOTA
DEPARTMENT OF TRANSPORTATION

POLE FOUNDATION - TYPE BA
ANCHOR BOLT DETAIL

SPECIFICATION REFERENCE
2565

STANDARD PLATE NO.
8134C
4 OF 4

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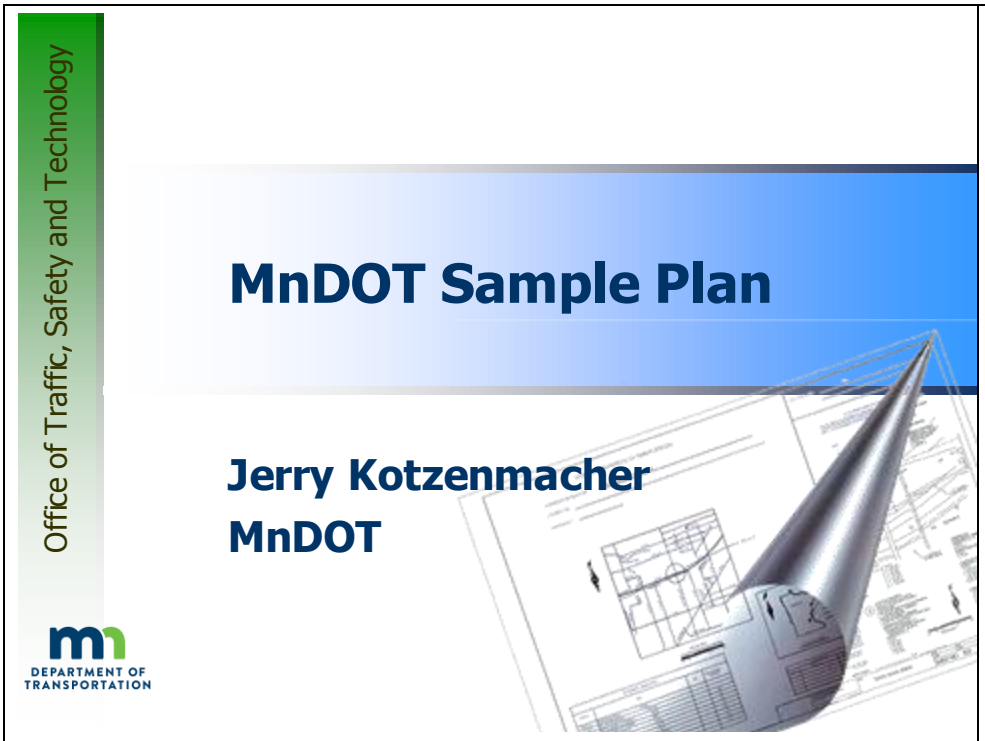
TOPIC 4: INTRODUCTION TO PLAN



In this chapter you will be introduced to a typical traffic signal plan sheet layout and wiring diagram. This will cover the typical items that are found in these plan sets.

A copy of the plan set is included at the back of this manual.

Office of Traffic, Safety and Technology

Traffic Signal Plans

– Why do we need a plan?

- Building the traffic signal.
- Bidding
- Tort Claims
- Maintenance
- Locates

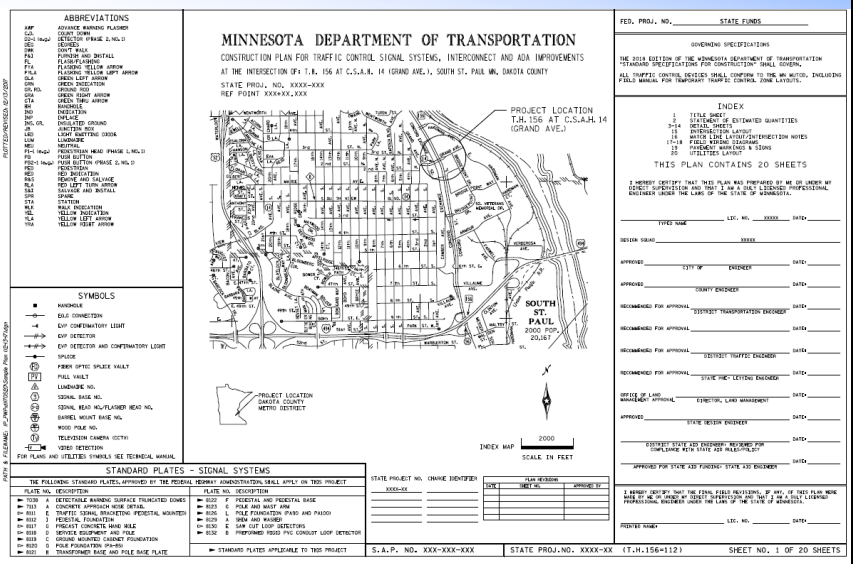
DEPARTMENT OF TRANSPORTATION

3

The purpose of the plan set.

Office of Traffic, Safety and Technology

Title Sheet – front page



DEPARTMENT OF TRANSPORTATION

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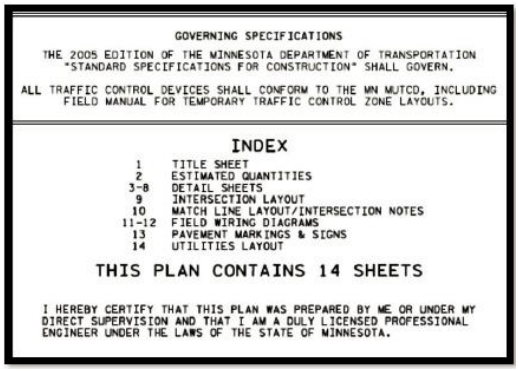
The title sheet is required for all traffic signal plans. It includes information such as the title block, project location, governing specifications, etc.

Office of Traffic, Safety and Technology

Title Sheet – front page

– Governing Specs and Index of Sheets

This defines the governing specifications for the project, the project funding and the index of the sheets contained within the plan set.



GOVERNING SPECIFICATIONS

THE 2005 EDITION OF THE MINNESOTA DEPARTMENT OF TRANSPORTATION "STANDARD SPECIFICATIONS FOR CONSTRUCTION" SHALL GOVERN.

ALL TRAFFIC CONTROL DEVICES SHALL CONFORM TO THE MN MUTCD, INCLUDING FIELD MANUAL FOR TEMPORARY TRAFFIC CONTROL ZONE LAYOUTS.

INDEX

1	TITLE SHEET
2	ESTIMATED QUANTITIES
3-8	DETAIL SHEETS
9	INTERSECTION LAYOUT
10	MATCH LINE LAYOUT/INTERSECTION NOTES
11-12	FIELD WIRING DIAGRAMS
13	PAVEMENT MARKINGS & SIGNS
14	UTILITIES LAYOUT

THIS PLAN CONTAINS 14 SHEETS

I HEREBY CERTIFY THAT THIS PLAN WAS PREPARED BY ME OR UNDER MY DIRECT SUPERVISION AND THAT I AM A DULY LICENSED PROFESSIONAL ENGINEER UNDER THE LAWS OF THE STATE OF MINNESOTA.

DEPARTMENT OF TRANSPORTATION

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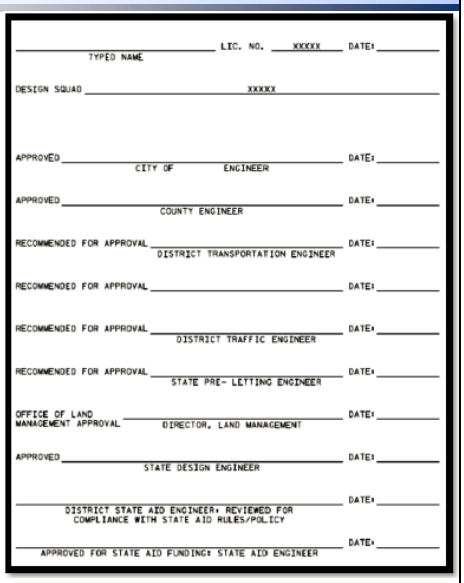
Office of Traffic, Safety and Technology

Title Sheet – front page

– Signature Block

The Designer should consult with the Mn/DOT project manager to ensure that the appropriate signature block is used.



_____ LIC. NO. XXXXX DATE: _____
TYPED NAME

DESIGN SQUAD _____ XXXXX

APPROVED _____ DATE: _____
CITY OF ENGINEER

APPROVED _____ DATE: _____
COUNTY ENGINEER

RECOMMENDED FOR APPROVAL _____ DATE: _____
DISTRICT TRANSPORTATION ENGINEER

RECOMMENDED FOR APPROVAL _____ DATE: _____

RECOMMENDED FOR APPROVAL _____ DATE: _____
DISTRICT TRAFFIC ENGINEER

RECOMMENDED FOR APPROVAL _____ DATE: _____
STATE PRE- LETTING ENGINEER

OFFICE OF LAND MANAGEMENT APPROVAL _____ DATE: _____
DIRECTOR, LAND MANAGEMENT

APPROVED _____ DATE: _____
STATE DESIGN ENGINEER

_____ DATE: _____
DISTRICT STATE AID ENGINEER, REVIEWED FOR COMPLIANCE WITH STATE AID RULES/POLICY

_____ DATE: _____
APPROVED FOR STATE AID FUNDING: STATE AID ENGINEER

DEPARTMENT OF TRANSPORTATION

The plan preparation certification note identifies:

- who the plan set was developed by (or under the direct supervision of)
- that individual's state registration information.

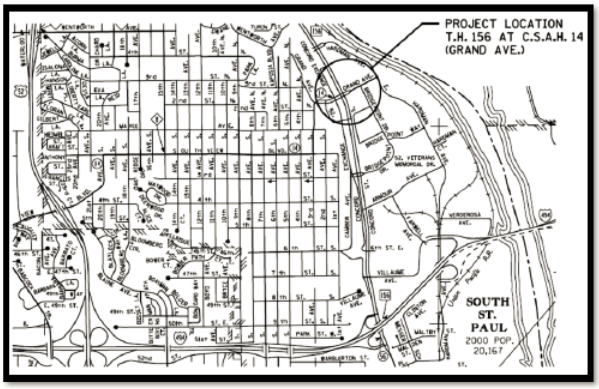
The signature block is contained on the title sheet and varies depending on the type of project.

Office of Traffic, Safety and Technology

Title Sheet – front page

– Index Map

The index map is used to identify the location of the project(s).



DEPARTMENT OF TRANSPORTATION

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The index map is used to identify the location of the project(s).

The project numbers and sheet numbers are shown in the lower right hand corner of the title sheet and on all other sheets. For revisions to the plan made after project advertisement, an "R" shall be used after the sheet number.

Office of Traffic, Safety and Technology

Title Sheet – front page

– Standard Plates Summary

This identifies the list of Standard Plates that are applicable to this project.

STANDARD PLATES - SIGNAL SYSTEMS

THE FOLLOWING STANDARD PLATES, APPROVED BY THE FEDERAL HIGHWAY ADMINISTRATION, SHALL APPLY ON THIS PROJECT

PLATE NO.		DESCRIPTION	PLATE NO.		DESCRIPTION
► 7036	G	PEDESTRIAN CURB RAMP PERPENDICULAR DESIGN	► 8121	G	TRANSFORMER BASE AND POLE BASE PLATE
► 7038	A	DETECTABLE WARNING SURFACE TRUNCATED DOMES	► 8122	F	PEDESTAL AND PEDESTAL BASE
► 7113	A	CONCRETE APPROACH NOSE DETAIL	► 8123	G	POLE AND MAST ARM
▻ 8111	E	TRAFFIC SIGNAL BRACKETING (PEDESTAL MOUNTED)	► 8126	J	POLE FOUNDATION (PA90 AND PA100)
► 8112	G	PEDESTAL FOUNDATION	► 8129	A	SHIM AND WASHER
▻ 8117	F	PRECAST CONCRETE HAND HOLE	▻ 8130	E	SAW CUT LOOP DETECTORS
▻ 8118	D	SERVICE EQUIPMENT AND POLE	▻ 8132	B	PREFORMED RIGID PVC CONDUIT LOOP DETECTOR
► 8119	C	GROUND MOUNTED CABINET FOUNDATION			
▻ 8120	P	POLE FOUNDATION (PA-85)			

► STANDARD PLATES APPLICABLE TO THIS PROJECT

DEPARTMENT OF TRANSPORTATION

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A list of applicable Standards Plates for the project is included in the plan set.

The estimated quantities may be included on a separate sheet or shown on the title sheet (if there is room). Traffic control interconnection, emergency vehicle preemption system, and other items such as conduit and handholes for a future signal system may be itemized separately from the signal system due to cost participation.

The appropriate specification item numbers, item descriptions, and units using the state's computerized pay item list shall be included.

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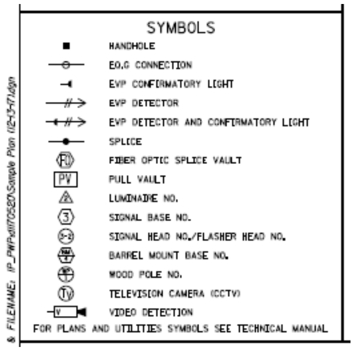
Title Sheet – front page

– Plan Symbols & Abbreviations

ABBREVIATIONS

AWF	ADVANCE WARNING FLASHER
C.D.	COUNT DOWN
D2-1 (e.g.)	DETECTOR (PHASE 2, NO. 1)
DEG	DEGREES
DWK	DON'T WALK
F&I	FURNISH AND INSTALL
FL	FLASH/FLASHING
FYA	FLASHING YELLOW ARROW
FYLA	FLASHING YELLOW LEFT ARROW
GLA	GREEN LEFT ARROW
GRN	GREEN INDICATION
GR. RD.	GROUND ROD
GRA	GREEN RIGHT ARROW
GTA	GREEN THRU ARROW
HH	HANDHOLE
IND	INDICATION
INP	INPLACE
INS. GR.	INSULATED GROUND
JB	JUNCTION BOX
LED	LIGHT EMITTING DIODE
LUM	LUMINAIRE
NEU	NEUTRAL
P1-1 (e.g.)	PEDESTRIAN HEAD (PHASE 1, NO. 1)
PB	PUSH BUTTON
PB2-1 (e.g.)	PUSH BUTTON (PHASE 2, NO. 1)
PED	PEDESTRIAN
RED	RED INDICATION
R&S	REMOVE AND SALVAGE
RLA	RED LEFT TURN ARROW
S&I	SALVAGE AND INSTALL
SPR	SPARE
STA	STATION
WLK	WALK INDICATION
YEL	YELLOW INDICATION
YLA	YELLOW LEFT ARROW
YRA	YELLOW RIGHT ARROW



DEPARTMENT OF TRANSPORTATION

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These are some of the common abbreviations used in a signal plan set.

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Title Sheet – page 2

– Quantity Sheet

STATEMENT OF ESTIMATED QUANTITIES				COST BREAKDOWN			
ITEM NO.	DESCRIPTION	UNIT	TOTAL ESTIMATED QUANTITIES	STATE SP XXXX-XX	COUNTY SAP XXX-XXX-XXX	FEDERAL SP XXXX-XX	CITY SAP XXX-XXX-XXX
2021.501	MOBILIZATION	LUMP SUM					
2104.501	REMOVE CURB AND GUTTER	LIN FT					
2104.503	REMOVE CONCRETE WALK	SQ FT					
2104.503	REMOVE BRICK MEDIAN	SQ FT					
2104.503	REMOVE BRICK SIDEWALK	SQ FT					
2104.603	REMOVE AND REPLACE BITUMINOUS PAVEMENT	LIN FT					
2104.618	SALVAGE BRICK PAVERS	SQ FT					
2232.603	MILL AND PATCH BITUMINOUS PAVEMENT	LIN FT					
2521.618	CONCRETE WALK	SQ FT					
2531.603	CONCRETE CURB AND GUTTER	LIN FT					
2565.511	CONCRETE CURB DESIGN V	LIN FT					
2531.618	TRUNCATED DOMES	SQ FT					
2563.601	TRAFFIC CONTROL	LUMP SUM					
2565.511	TRAFFIC CONTROL SIGNAL SYSTEM	SIG SYS					
2565.601	EMERGENCY VEHICLE PREEMPTION SYSTEM	LUMP SUM					
2565.601	TRAFFIC CONTROL INTERCONNECTION	LUMP SUM					
2565.616	REVISE SIGNAL SYSTEM	SYSTEM					

DEPARTMENT OF TRANSPORTATION

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Earthwork summary tabulations may be included if this signal project is part of a construction project.

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ALL SHEETS

– Title Block

The title block is required on all sheets. For the intersection layout sheet the signal system ID, meter address and TE number should be included

DEPARTMENT OF TRANSPORTATION

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Title Block.

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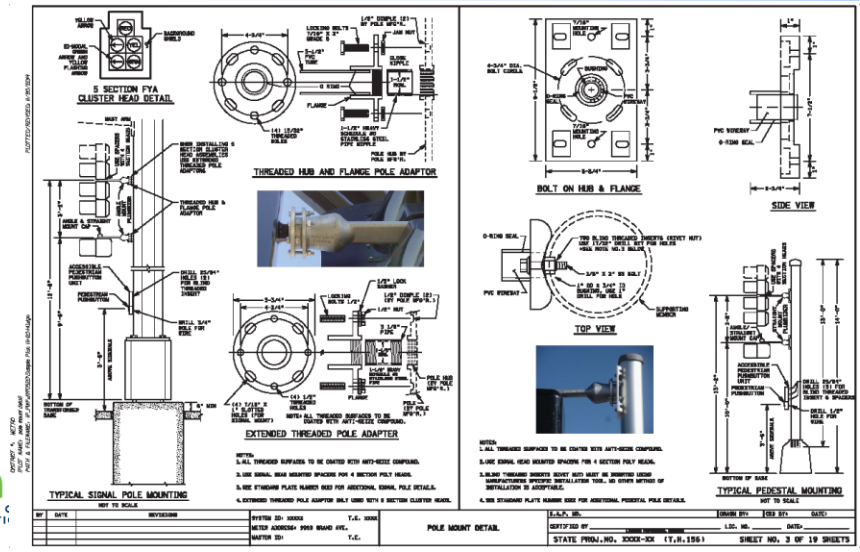
Page 3 – Pole Mount Detail



DEPARTMENT OF TRANSPORTATION

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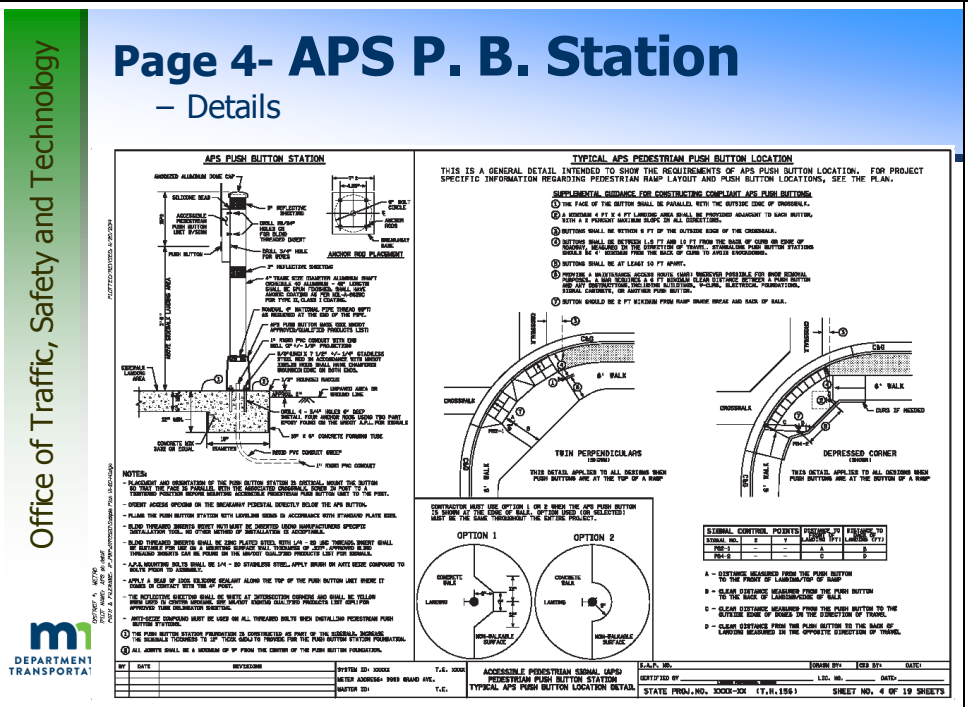
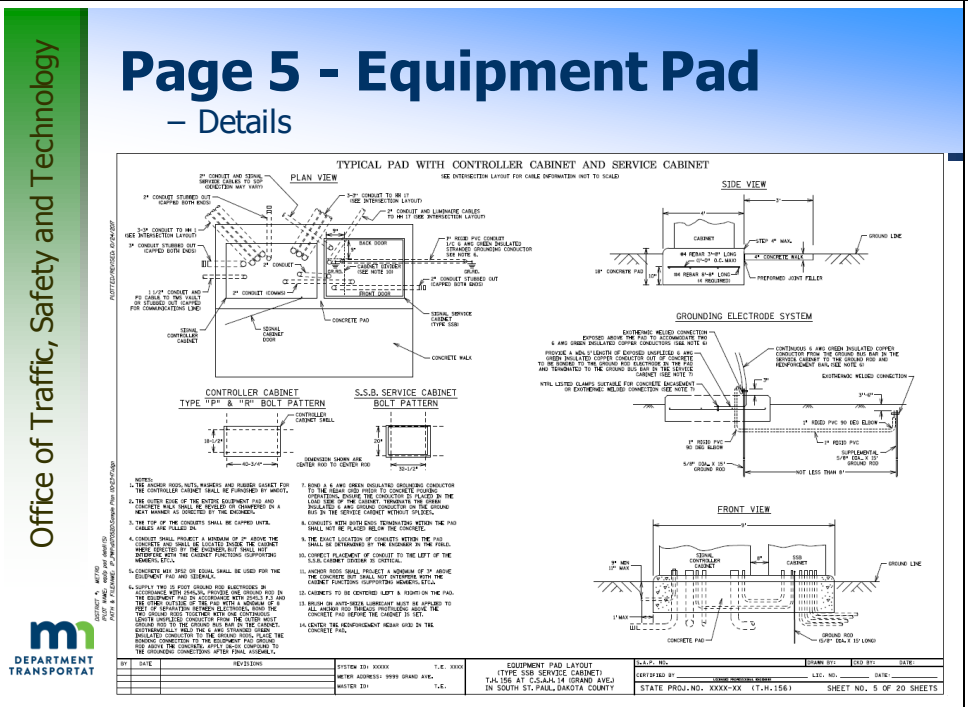
The pole mount details for angle and straight mounts.



This detail shows the accessible pedestrian signal (APS) Push Button (PB) details.



The equipment pad layout sheet shows the details for the equipment pad. The concrete pad in the picture is the equipment pad for the traffic signal controller and service cabinet.

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Controller & Service Cabinet

DEPARTMENT OF TRANSPORTATION

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Picture of the traffic signal controller cabinet (left) and service cabinet (right).

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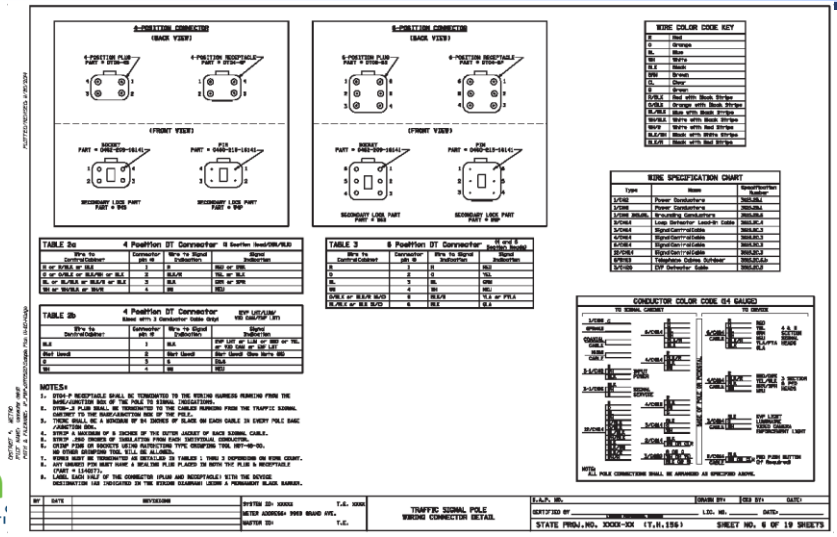
Page 6 -Pole Wiring Connector

– Details



DEPARTMENT TRANSPORTATI

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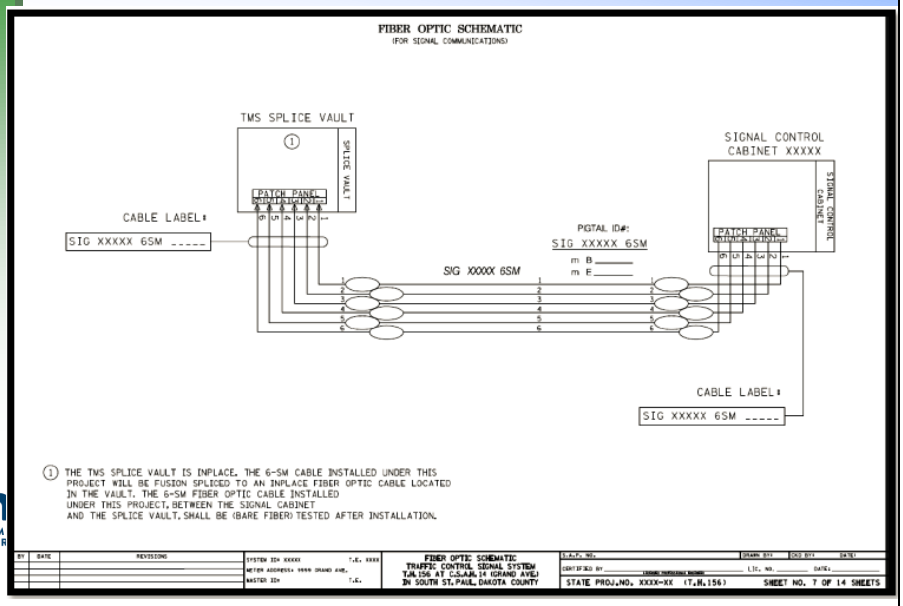
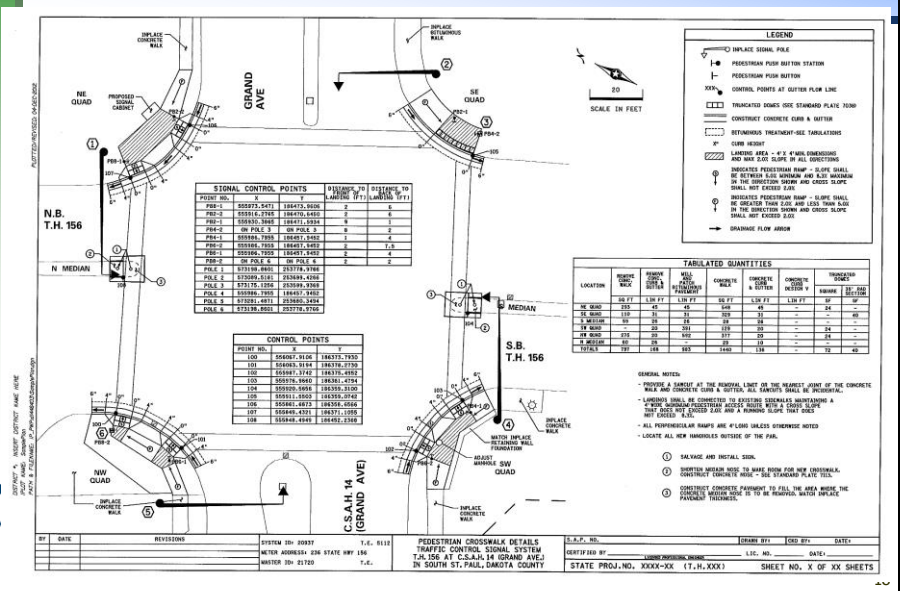
This is the pole base wire connector details sheet.

Page 7 – Fiber Optic Schematic
– Details



This is the fiber optic schematic detail sheet (if applicable).

Page 8 – Ped Curb Ramp
– Details



This shows the layout of the pedestrian curb ramps.

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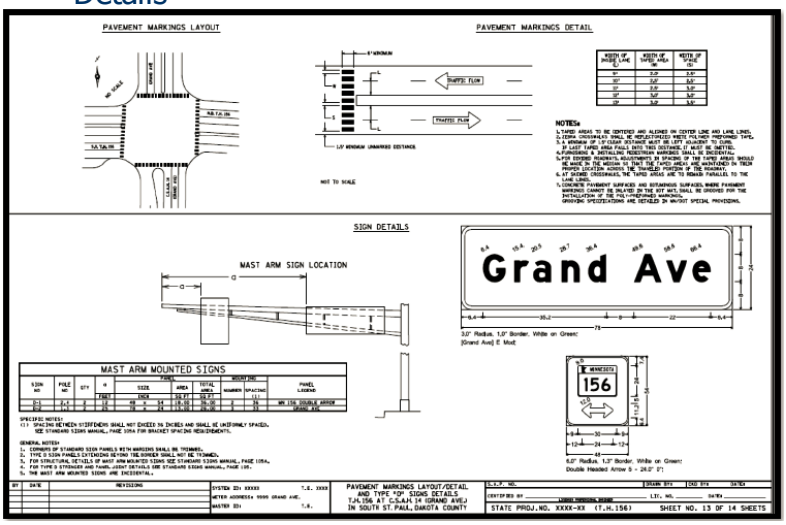
Page 19 – Pavement Markings & Signs

– Details



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The detail sheet for pavement markings and signing.

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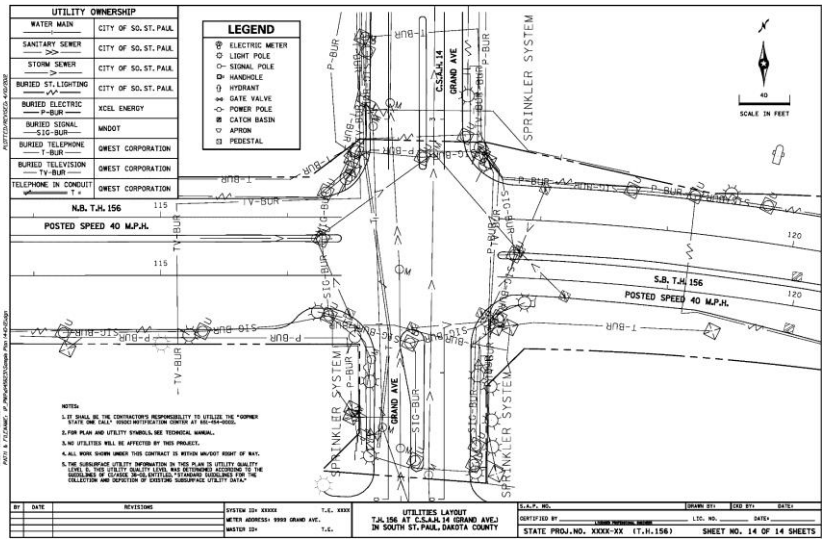
Page 20 – Utilities Layout



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This is a plan sheet view of the public utilities.

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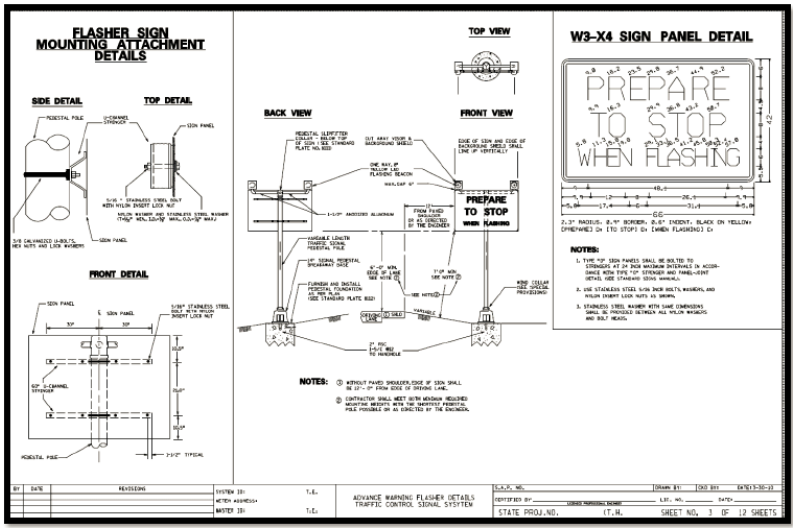
DEPARTMENT OF TRANSPORTATION

Not part of your plan

– Details



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This is the detail sheet for the advance warning flasher. The pictures show some typical AWF installations. Also see topic 10 for more information on AWF.

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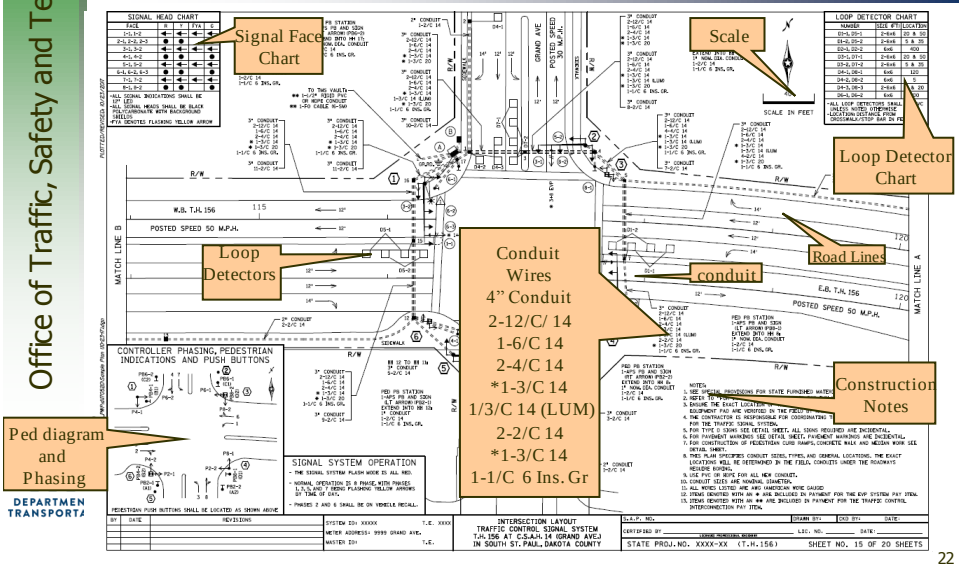
DEPARTMENT OF TRANSPORTATION

Page 15 - Signal Layout



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This is a typical plan sheet signal layout. A copy of this layout is found in the Appendix.

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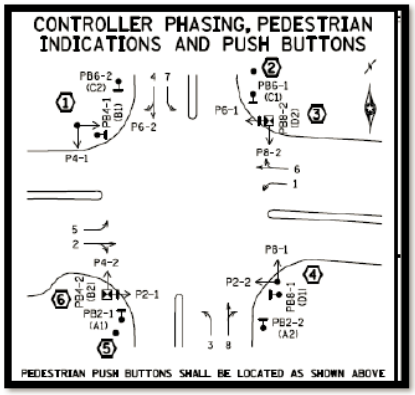
Page 15– Intersection Layout

– Typical Controller Phasing Diagram

8 phase NEMA Controller



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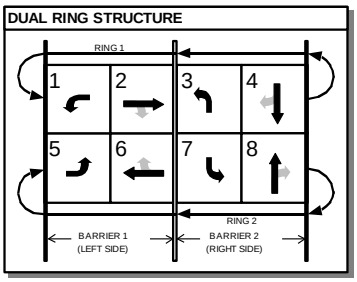
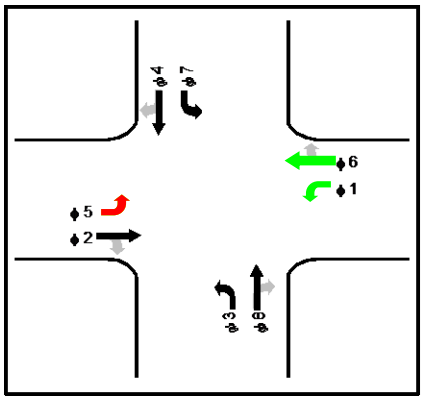
Controller Operations

– Phasing

– Dual-ring and Concurrent group Controllers





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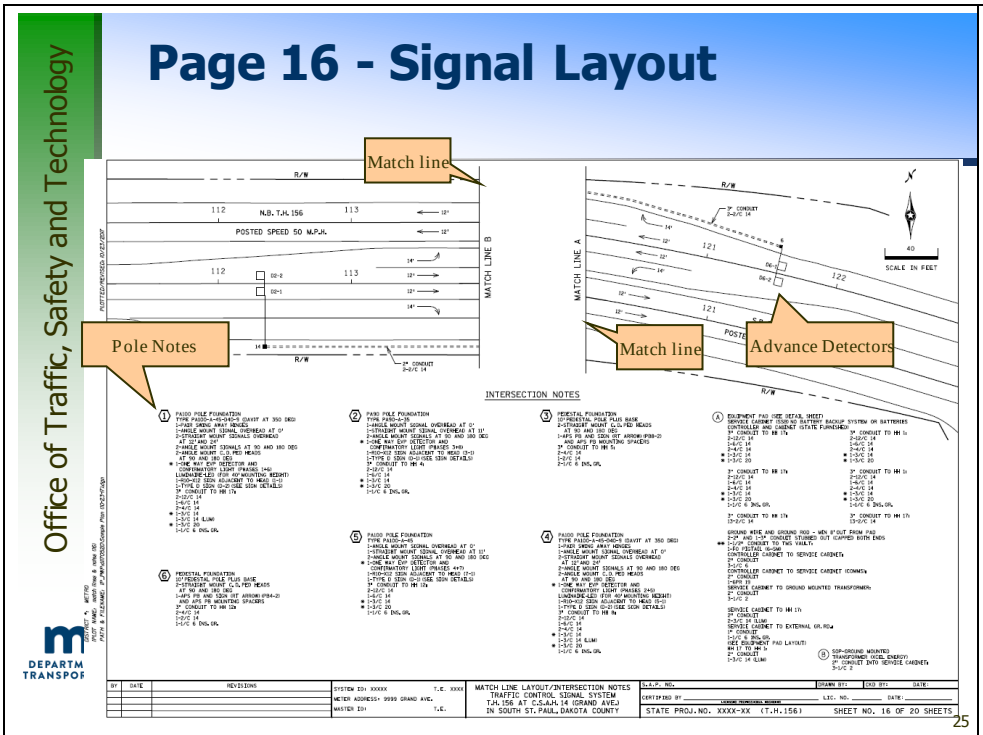
Dual ring and concurrent group controllers. Refer to Chapter 7 for additional details.



This is the match line sheet of the signal layout. This sheet shows the advance detectors.

The intersection layout sheet includes the following (at a minimum):

- Intersection geometrics
- All graphics depicting signal system components
- Controller phasing diagram
- Signal system operation notes
- Signal faces table
- Loop detectors table
- Signal pole notes
- Equipment pad notes
- Source of power notes
- Construction notes
- Signal system ID, meter address and TE number
- A scale
- A north arrow
- Speed limits
- Street names
- Metric logo
- DO NOT show utilities on the layout sheet, include additional sheet(s) for utilities.

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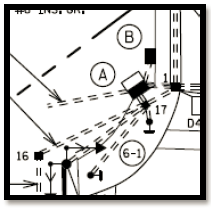
Page 15 & 16 – Intersection Layout

- Equipment Pad and SOP Notes



B SOP-GROUND MOUNTED
TRANSFORMER (XCEL ENERGY)
2" CONDUIT INTO SERVICE CABINET:
3-1/C #2

A EQUIPMENT PAD (SEE DETAIL SHEET)
SERVICE CABINET (SSB) NO BATTERY BACKUP SYSTEM OR BATTERIES
CONTROLLER AND CABINET (STATE FURNISHED)
3" CONDUIT TO HH 17:
2-12/C 14
1-6/C 14
2-4/C 14
* 1-3/C 14
* 1-3/C 20

3" CONDUIT TO HH 17:
2-12/C 14
1-6/C 14
2-4/C 14
* 1-3/C 14
* 1-3/C 20
1-1/C 6 INS. GR.

3" CONDUIT TO HH 17:
13-2/C 14

3" CONDUIT TO HH 1:
2-12/C 14
1-6/C 14
2-4/C 14
* 1-3/C 14
* 1-3/C 20

3" CONDUIT TO HH 1:
2-12/C 14
1-6/C 14
2-4/C 14
* 1-3/C 14
* 1-3/C 20
1-1/C 6 INS. GR.

3" CONDUIT TO HH 17:
13-2/C 14

GROUND WIRE AND GROUND ROD - MIN. 8' OUT FROM PAD
2-2" AND 1-3" CONDUIT STUBBED OUT (CAPPED BOTH ENDS
** 1-1/2" CONDUIT TO TMS VAULT:
1-FO PIGTAIL (6-SM)
CONTROLLER CABINET TO SERVICE CABINET:
2" CONDUIT
3-1/C 6
CONTROLLER CABINET TO SERVICE CABINET (COMMS):
2" CONDUIT
1-6PR 19
SERVICE CABINET TO GROUND MOUNTED TRANSFORMER:
2" CONDUIT
3-1/C 2

Label, in a circle, the controller cabinet or equipment pad "A" and the source of power "B"

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The equipment pad note is shown as a circled "A".

A solid (filled) symbol identifies new equipment and an open symbol identifies in-place equipment.

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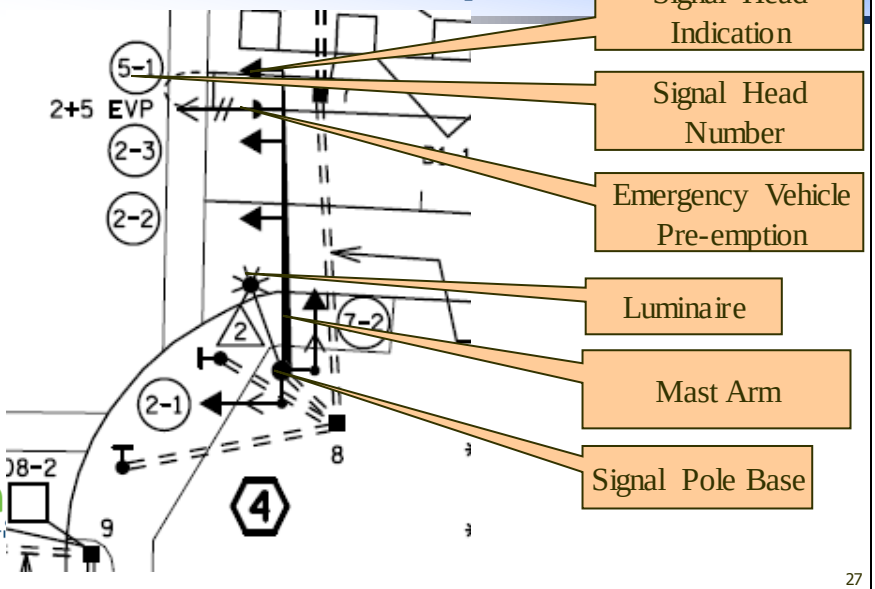
Page 15 – Intersection Layout Mast Arm & Pole _Symbols



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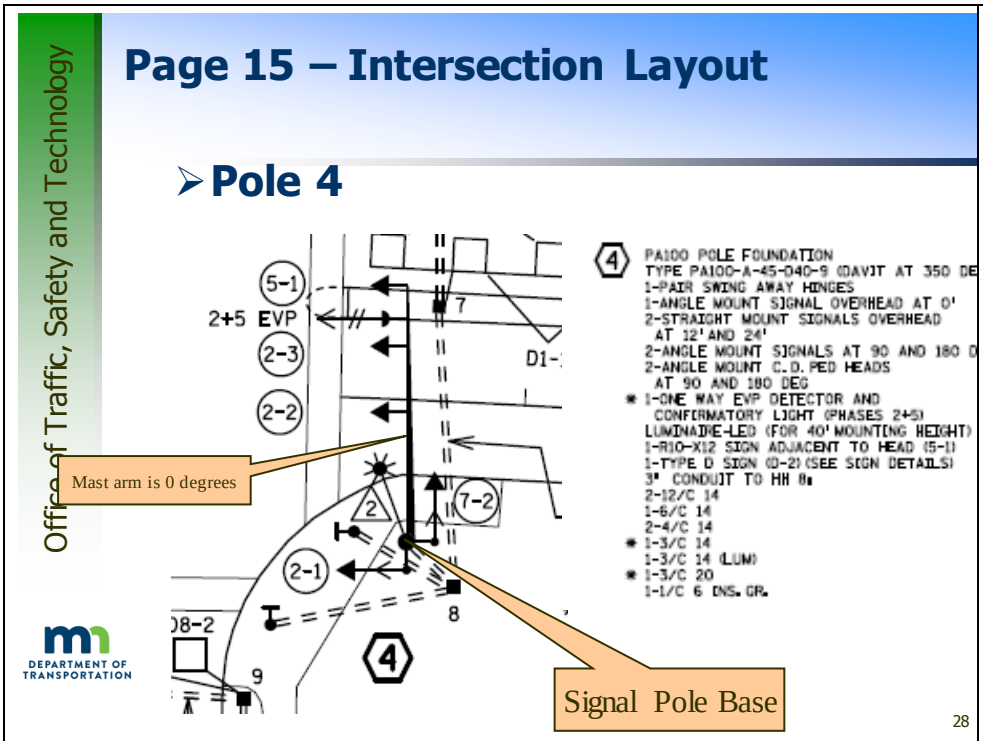
The signal bases and pole notes are shown in a hexagon. The signal bases are labeled clockwise around the intersection with Number 1 being adjacent to or near the controller cabinet.

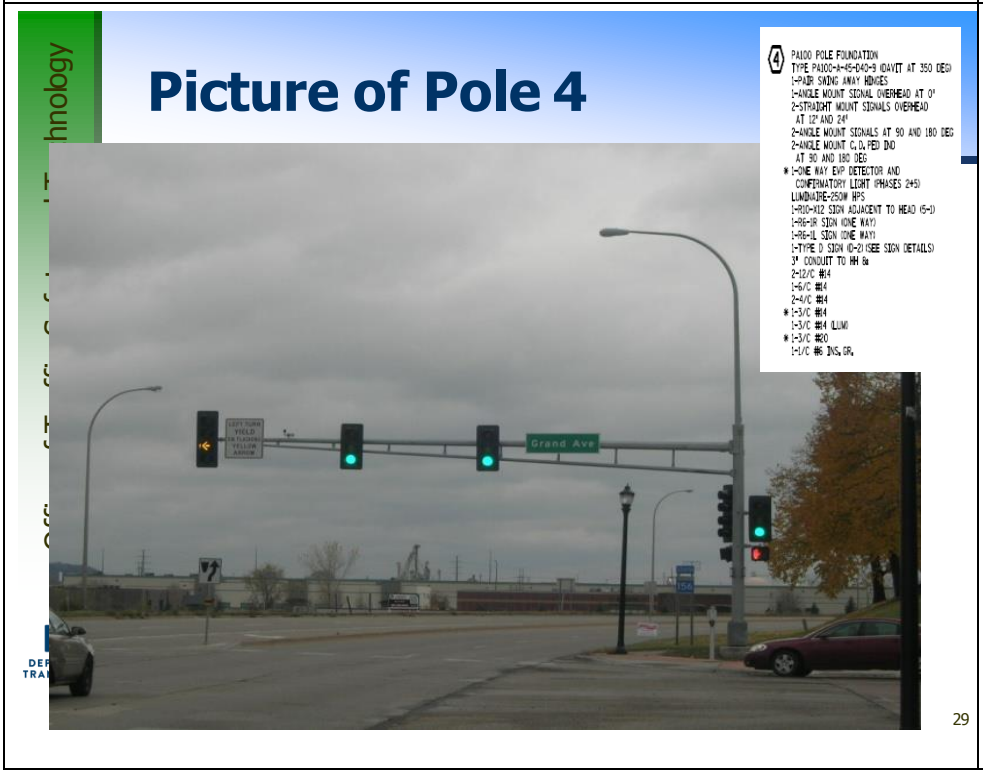
A solid filled symbol identifies new equipment and an open symbol identifies in-place equipment.

The vehicle signal face is identified with the filled triangle (proposed). The faces are labeled from right to left as you approach the intersection.

Signal faces are numbered with the controller phase first, followed by the face number (for example 2-1, 2-2, etc.).



These are the signal pole notes. The mast-arm is at 0 degrees. Items referenced with angles are in relation to the mast arm pole in the clockwise direction.



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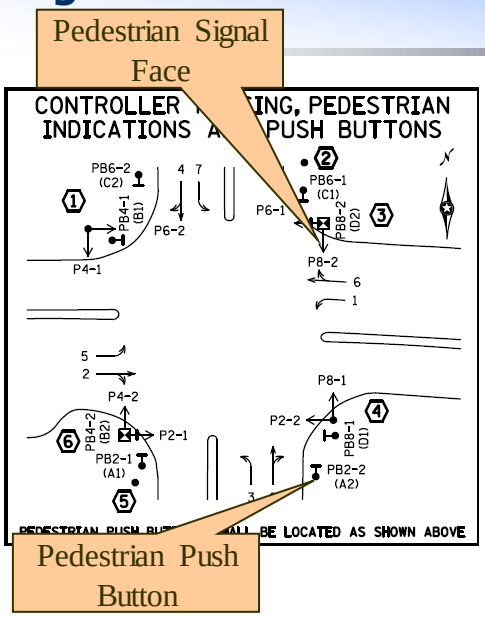
Page 15 – Intersection Layout



30

The pedestrian signal face is illustrated with as an arrow. The face is numbered as you approach the intersection with Number 1 being the first on the right and Numbers 2, 3, and 4 as you proceed through the intersection. The labels are preceded by a P with the controller phase number (for example P4-3, P4-4, etc.).

The pedestrian push button is labeled with a PB and the controller phase number.

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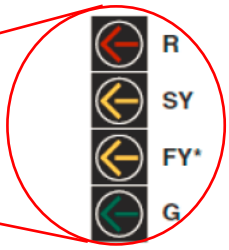
Page 15 – Intersection Layout

– Signal Faces Table

SIGNAL FACE CHART				
FACE	R	Y	FYA	G
1-1, 1-2	←	←	←	←
2-1, 2-2, 2-3	●	●		●
3-1, 3-2	←	←	←	←
4-1, 4-2	●	●		●
5-1, 5-2	←	←	←	←
6-1, 6-2, 6-3	●	●		●
7-1, 7-2	←	←	←	←
8-1, 8-2	●	●		●

-ALL SIGNAL INDICATIONS SHALL BE 12" LED
-ALL SIGNAL HEADS SHALL BE BLACK POLYCARBONITE WITH BACKGROUND SHIELDS
-FYA DENOTES FLASHING YELLOW ARROW



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The signal indications table identifies the face configuration for the signals shown on the plan sheet. The Face identification number refers to the signal face identifier number (circled number such as 2-1) shown on the plan sheet.

R = Red indication

Y = Yellow indication

G = Green indication

LED = Light Emitting Diode indication

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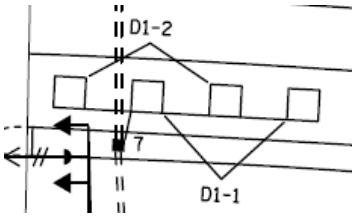
Page 15 – Intersection Layout

– Loop Detectors Table

LOOP DETECTOR CHART		
NUMBER	SIZE (FT)	LOCATION
D1-1, D5-1	2-6x6	20 & 50
D1-2, D5-2	2-6x6	5 & 35
D2-1, D2-2	6x6	400
D3-1, D7-1	2-6x6	20 & 50
D3-2, D7-2	2-6x6	5 & 35
D4-1, D8-1	6x6	120
D4-2, D8-2	2-6x6	0 & 15
D4-3, D8-3	2-6x6	5 & 20
D6-1, D6-2	6x6	400

-ALL LOOP DETECTORS SHALL BE PVC UNLESS NOTED OTHERWISE
-LOCATION: DISTANCE FROM CROSSWALK/STOP BAR IN FEET



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Loop detectors are shown with a square or rectangle. The detectors are normally labeled as you approach the intersection and from right to left with Number 1 usually a detector back from the stop line and Number 2 to the left. These numbers are proceeded by a D and the controller phase number (for example D8-1, D8-2, etc.).

The loop detector table identifies the size, number and location of the detector shown on the plan sheet. The detector number refers to the detector shown on the intersection plan sheet. The location shows the distance from the stop line to the detector.

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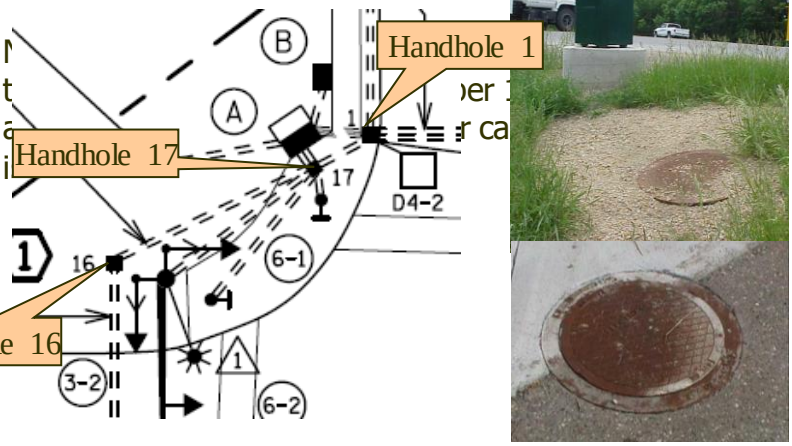
Page 15 – Intersection Layout

– Handhole Labeling



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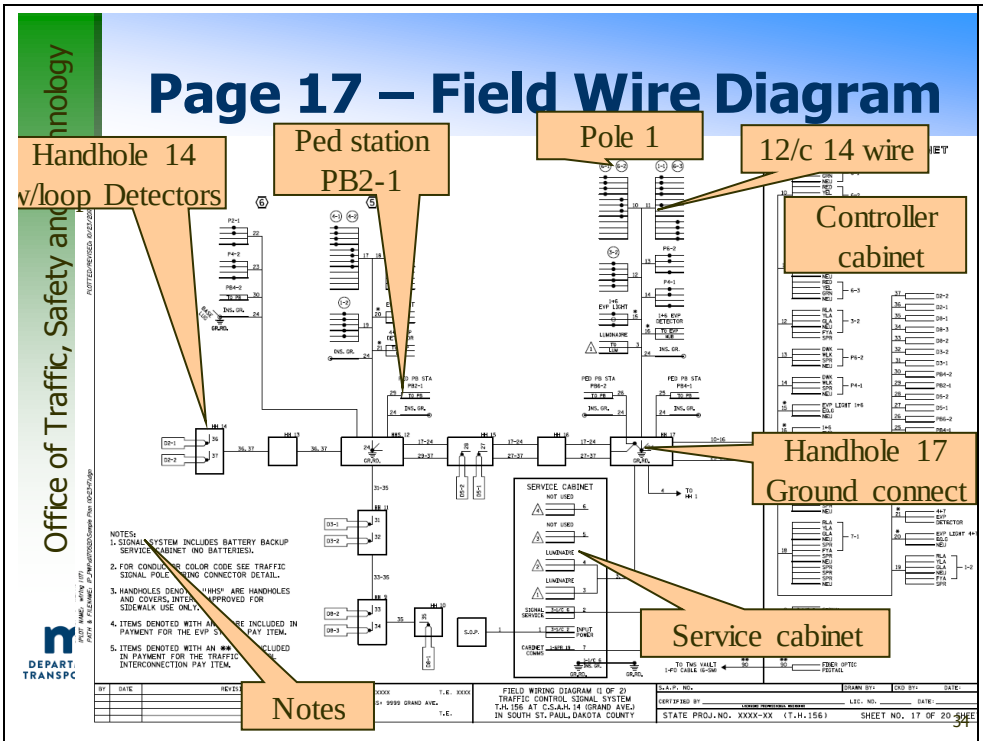
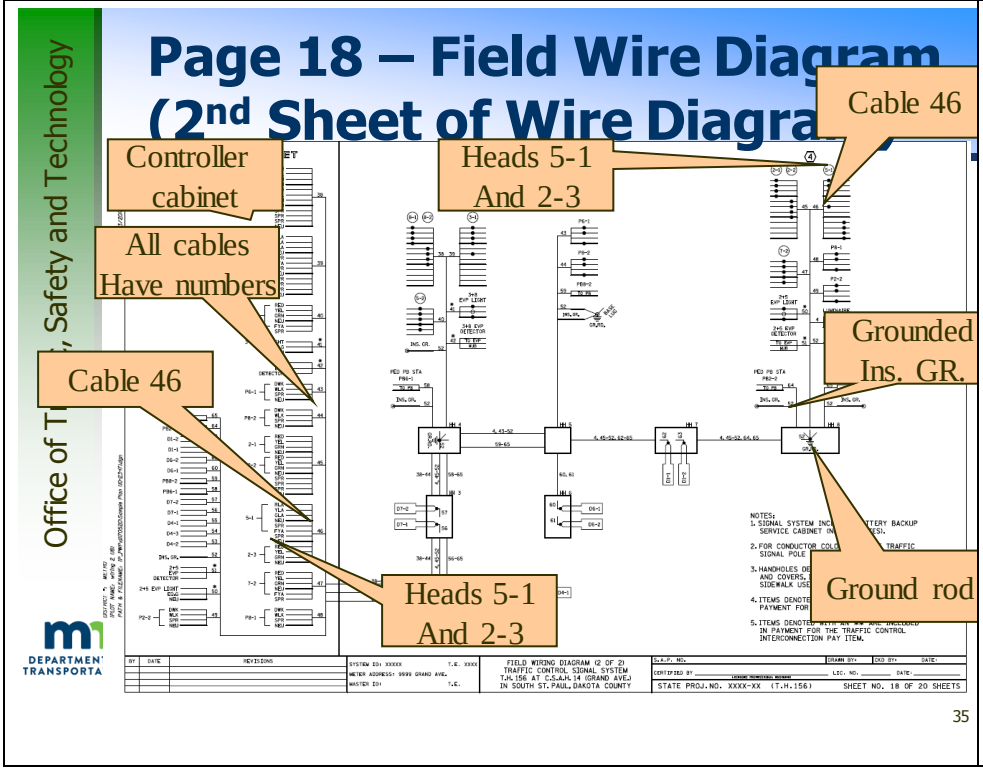
The handholes are shown as the solid black square (v) on the plan sheet.



The Field Wiring diagram.



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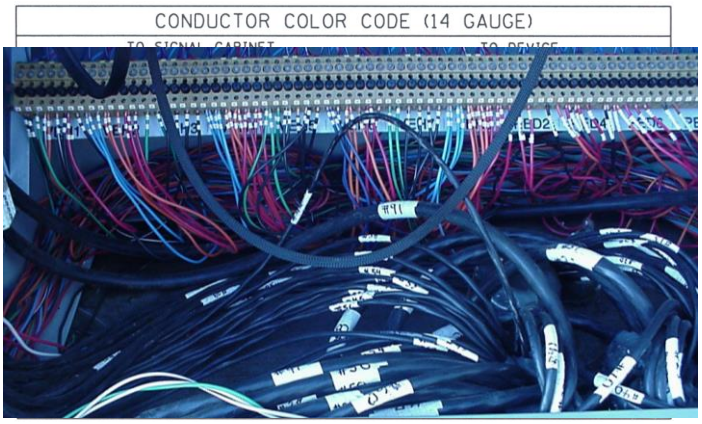
Wiring Diagram

- **Field Wiring**



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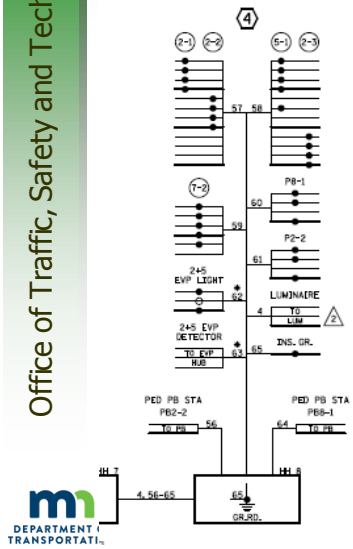
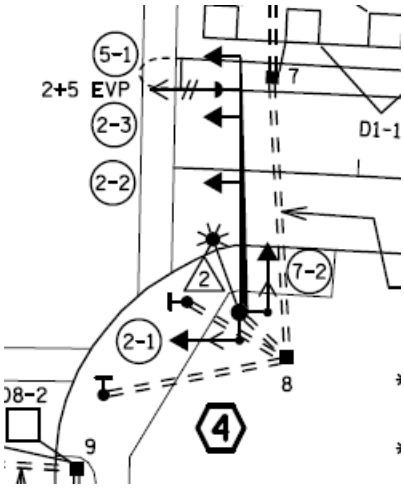
Wire Diagram to Layout Cross reference



page 18



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Pole #4 wire diagram to layout sheet.

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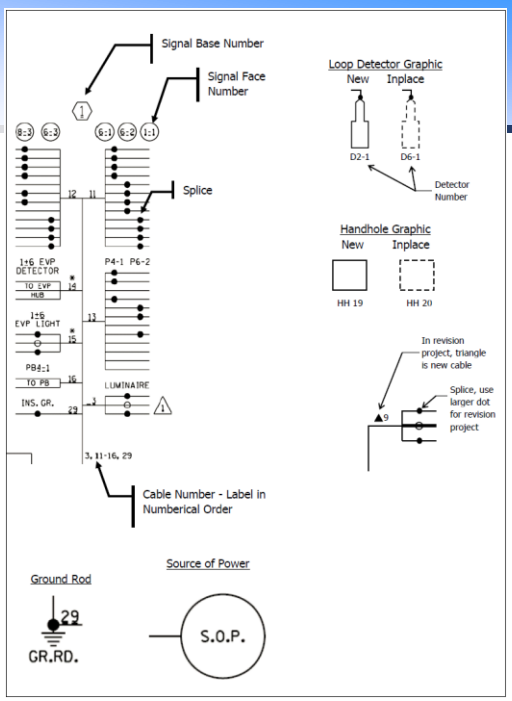
Wiring Notes

– Field Wiring



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The field wiring diagram is used to describe how the actual field wiring shall be placed.

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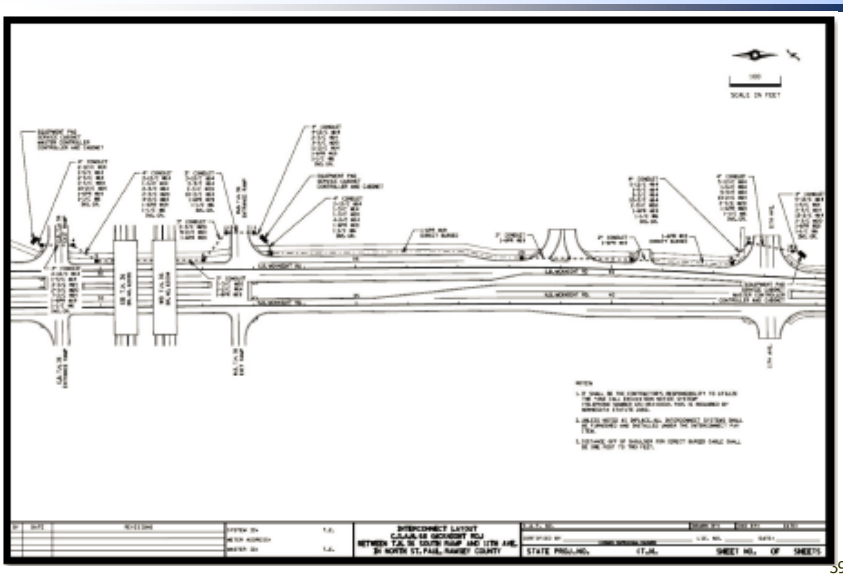
Interconnect layout – NOT PART OF YOUR PLAN



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This plan sheet shows interconnect for the project. Interconnect is a means of remotely controlling some or all of the functions of a traffic signal. It also allows the master controller to communicate with any local controllers in the system.

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Other Material Reference

- **MnDOT Manuals**
  - Signal Design Manual
  - Roadway Lighting Manual
  - Signal Timing Manual
  - Traffic Engineering Manual
  - MN-MUTCD

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➢ Questions?

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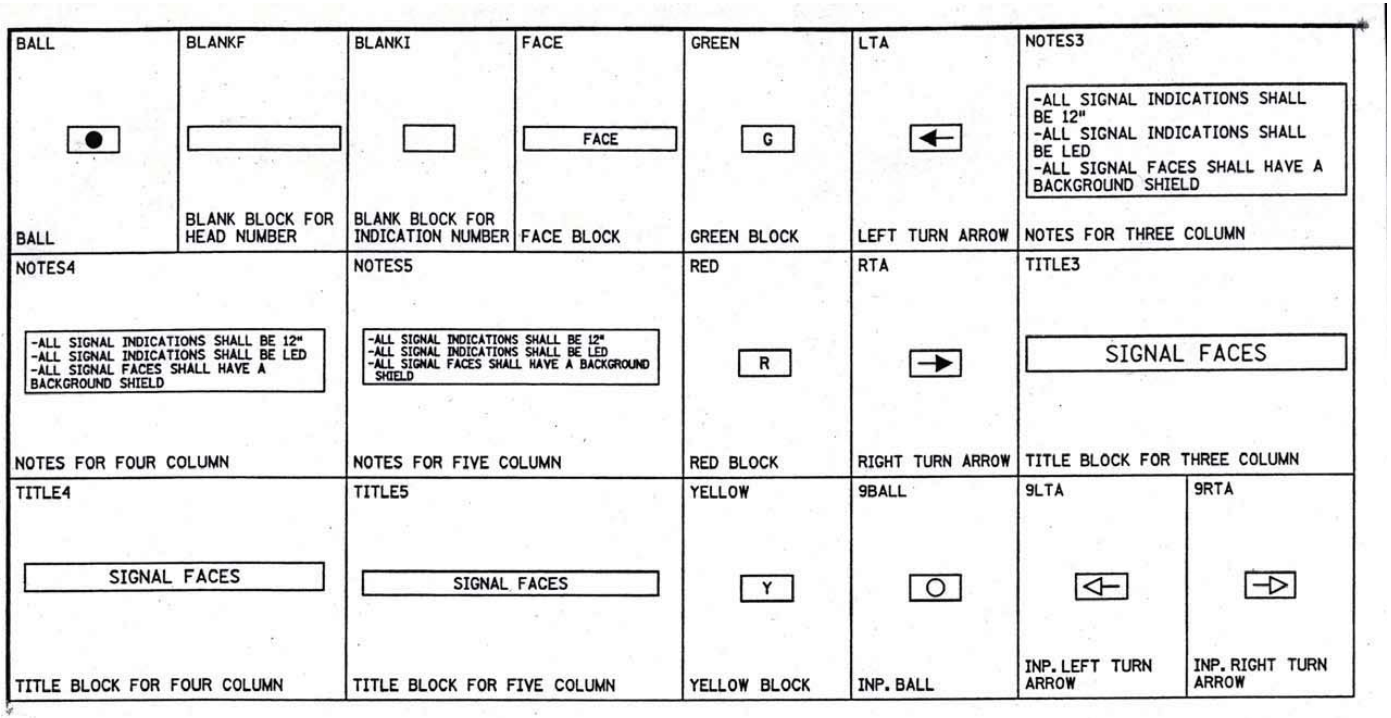
Handout

MnDOT Signal Cell Library

For the latest version, please visit:

http://www.dot.state.mn.us/caes/cadd/

HANDOUT



MN/DOT Signal Cell Library located at:

http://www.dot.state.mn.us/caes/cadd/download/index.html#cell

Download all libraries from this table

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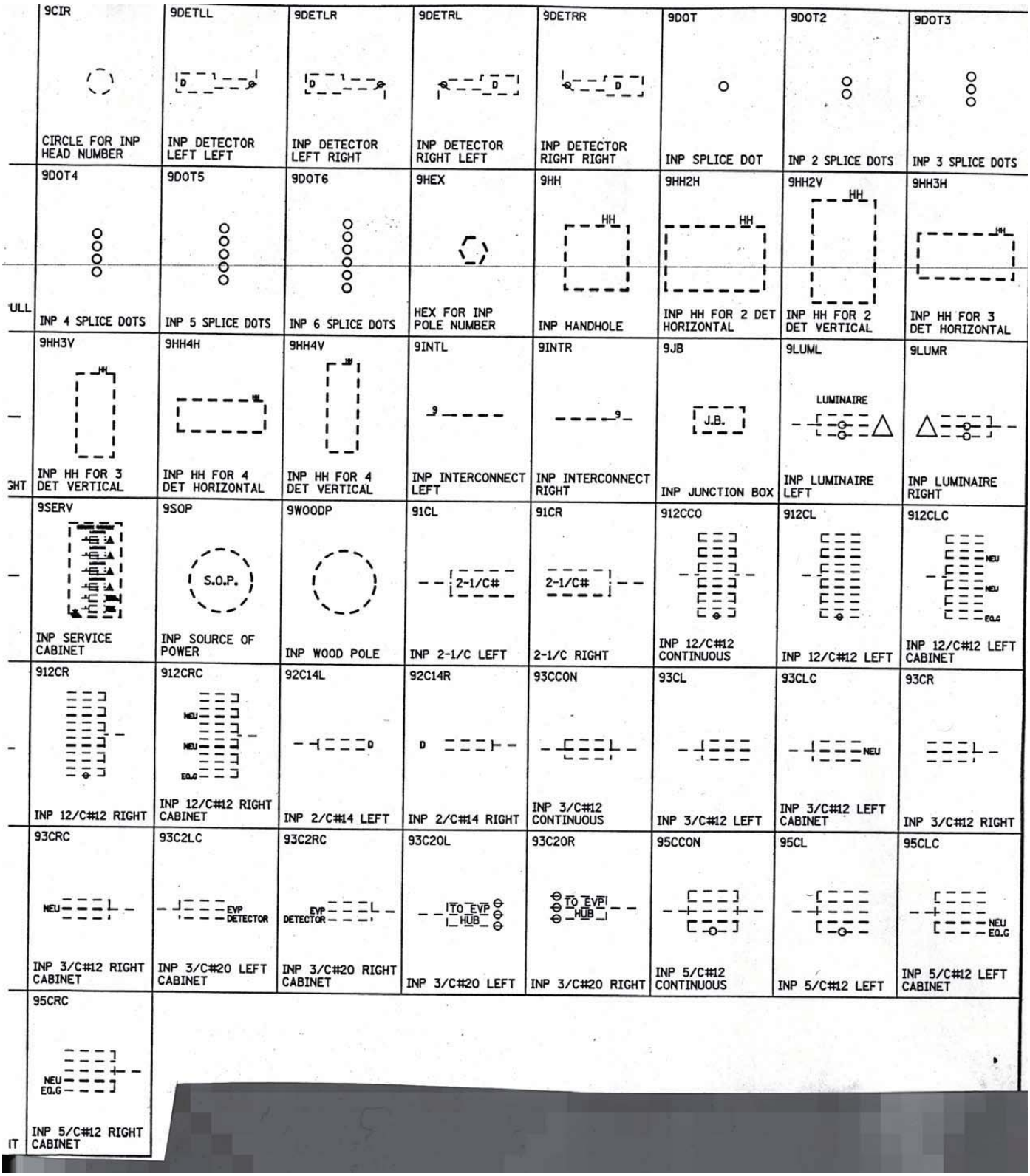
35MAA 35 FT MAST ARM ASSEMBLY	4A TYPE 4A PEDESTAL	4B TYPE 4B PEDESTAL	4C TYPE 4C PEDESTAL	4D TYPE 4D PEDESTAL	40MA 40 FT MAST ARM	40MAA 40 FT MAST ARM ASSEMBLY	45MAA 45 FT MAST ARM
45MAA 45 FT MAST ARM ASSEMBLY	5A TYPE 5A PEDESTAL	5B TYPE 5B PEDESTAL	5C TYPE 5C PEDESTAL	5D TYPE 5D PEDESTAL	5E TYPE 5E PEDESTAL	50MA 50 FT MAST ARM	50MAA 50 FT MAST ARM ASSEMBLY
55MA 55 FT MAST ARM	55MAA 55 FT MAST ARM ASSEMBLY	6A TYPE 6A PEDESTAL	6B TYPE 6B PEDESTAL	6C TYPE 6C PEDESTAL	6D TYPE 6D PEDESTAL	60MA 60 FT MAST ARM	60MAA 60 FT MAST ARM ASSEMBLY
65MA 65 FT MAST ARM	65MAA 65 FT MAST ARM ASSEMBLY	7A TYPE 7A PEDESTAL	7B TYPE 7B PEDESTAL	7C TYPE 7C PEDESTAL	7D TYPE 7D PEDESTAL	9CIR CIRCLE FOR INP HEAD NUMBER	9DET10 INP 6X10 LOOP DETECTOR
9DET15 INP 6X15 LOOP DETECTOR	9DET20 INP 6X20 LOOP DETECTOR	9DET6 INP 6X6 LOOP DETECTOR	9EVPL INP EVP LIGHT	9EVPS INP EVP SENSOR	9EVPSL INP EVP SENSOR AND LIGHT	9FLASH INP FLASHER HEAD	9HEX HEXAGON FOR INP HEAD NUMBER
9HH INP HANDHOLE	9JB INP JUNCTION BOX	9LUMO INP LUMINAIRE AT 0°	9LUM35 INP LUMINAIRE AT 350°	9PAD INP EQUIPMENT PAD	9PED INP PEDESTAL	9POLE INP MAST ARM OR WOOD POLE	9SIG INP SIGNAL HEAD
9SIG12 INP SIGNAL HEAD OFFSET 12 FT	91A INP TYPE 1A PEDESTAL	91B INP TYPE 1B PEDESTAL	91C INP TYPE 1C PEDESTAL	91D INP TYPE 1D PEDESTAL	91E INP TYPE 1E PEDESTAL	910A INP TYPE 10A	910A90 INP TYPE 10A AT 90°
910B INP TYPE 10B	910B90 INP TYPE 10B AT 90°	910C INP TYPE 10C	915MAA INP 15 FT MAST ARM ASSEMBLY	92A INP TYPE 2A PEDESTAL	92B INP TYPE 2B PEDESTAL	92C INP TYPE 2C PEDESTAL	92D INP TYPE 2D PEDESTAL

ANCHOR WOOD POLE ANCHOR	ARRL LANE ARROW LEFT	ARRLT LANE ARROW LEFT THRU	ARRLTR LANE ARROW LEFT THRU RIGHT	ARRNOR NORTH ARROW	ARRR LANE ARROW RIGHT	ARRT LANE ARROW THRU	ARRTR LANE ARROW THRU RIGHT
CIRC CIRCLE FOR HEAD NUMBER	DET10 6X10 LOOP DETECTOR	DET15 6X15 LOOP DETECTOR	DET20 6X20 LOOP DETECTOR	DET6 6X6 LOOP DETECTOR	EVPL EVP LIGHT	EVPS EVP SENSOR	RED EVP SENSOR AND LIGHT
FLASH FLASHER HEAD	GRRD GR.RD. GROUND ROD	HEX HEXAGON FOR POLE NUMBER	HH HANDHOLE	JB JUNCTION BOX	LUMO LUMINAIRE AT 0°	LUM350 LUMINAIRE AT 350°	PAD EQUIPMENT PAD
PED PEDESTAL	POLE MAST ARM OR WOOD POLE	RAMP PEDESTRIAN RAMP	SCA40 40' SCALE 40 SCALE	SHPB SIGNAL HEAD PHASING BOX	SHPB2 SIGNAL HEAD PHASING BOX	SIG SIGNAL HEAD	SIG12 SIGNAL HEAD OFFSET 12 FEET
TRI TRIANGLE FOR LUMINAIRE NUMBER	1A TYPE 1A PEDESTAL	1B TYPE 1B PEDESTAL	1C TYPE 1C PEDESTAL	1D TYPE 1D PEDESTAL	1E TYPE 1E PEDESTAL	10A TYPE 10A	10A90 TYPE 10A AT 90°
10B TYPE 10B	10B90 TYPE 10B AT 90°	10C TYPE 10C	15MA 15 FT MAST ARM	15MAA 15 FT MAST ARM ASSEMBLY	2A TYPE 2A PEDESTAL	2B TYPE 2B PEDESTAL	2C TYPE 2C PEDESTAL
2D TYPE 2D PEDESTAL	20A TYPE 20A	20B TYPE 20B	20C TYPE 20C	20MA 20 FT MAST ARM	20MAA 20 FT MAST ARM ASSEMBLY	25MA 25 FT MAST ARM	25MAA 25 FT MAST ARM ASSEMBLY
3A TYPE 3A PEDESTAL	3B TYPE 3B PEDESTAL	3C TYPE 3C PEDESTAL	30A TYPE 30A	30B TYPE 30B	30MA 30 FT MAST ARM	30MAA 30 FT MAST ARM ASSEMBLY	35MA 35 FT MAST ARM



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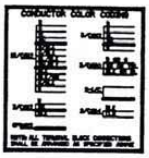
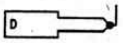
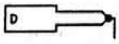
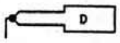
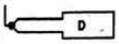
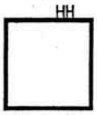
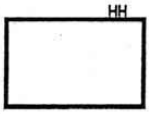
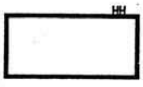
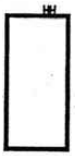
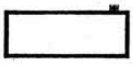
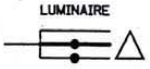
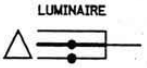
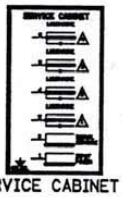
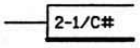
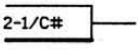
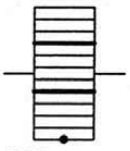
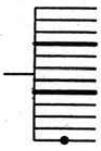
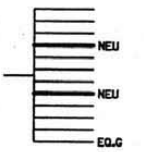
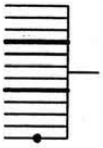
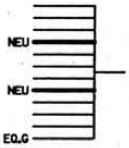
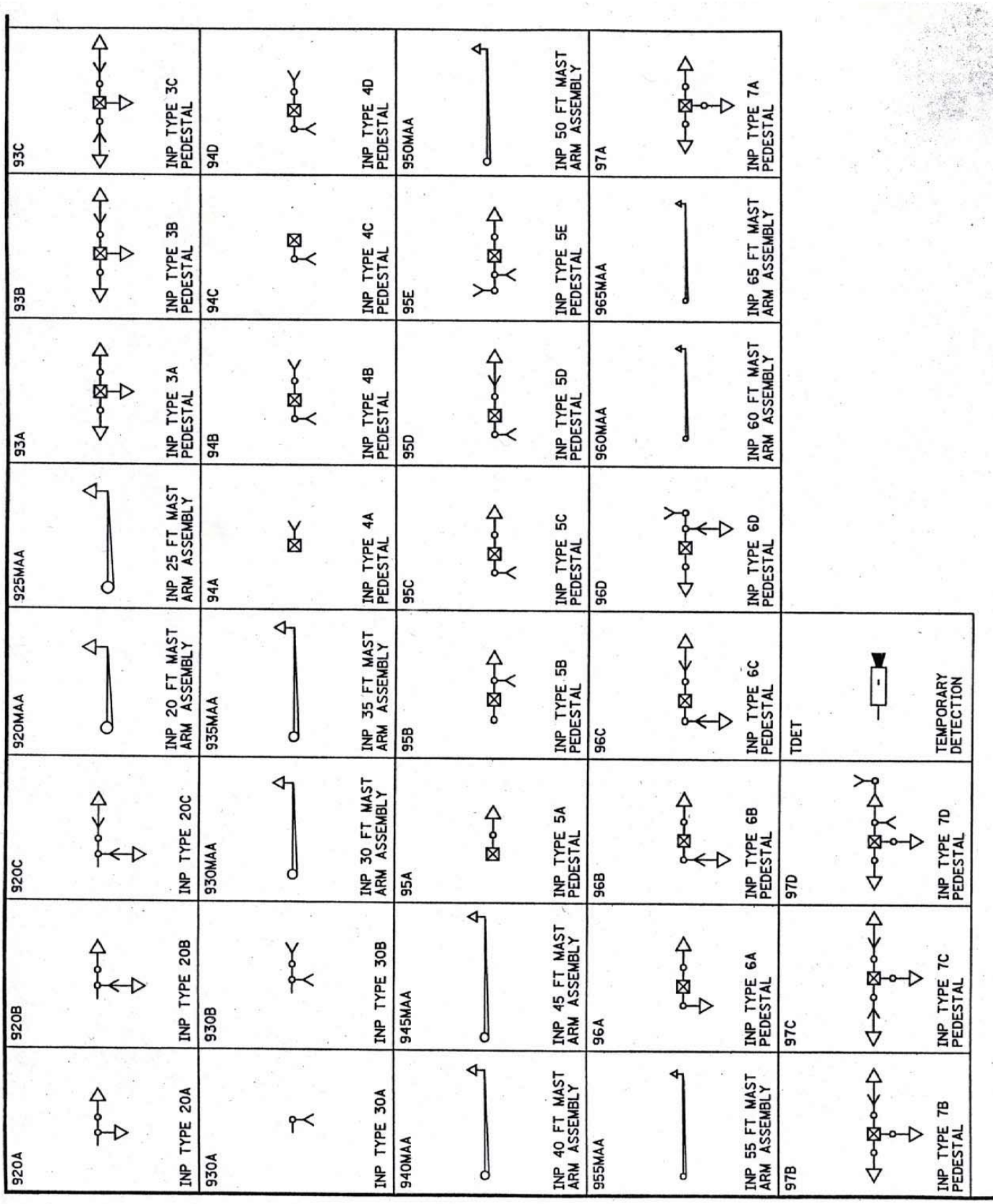
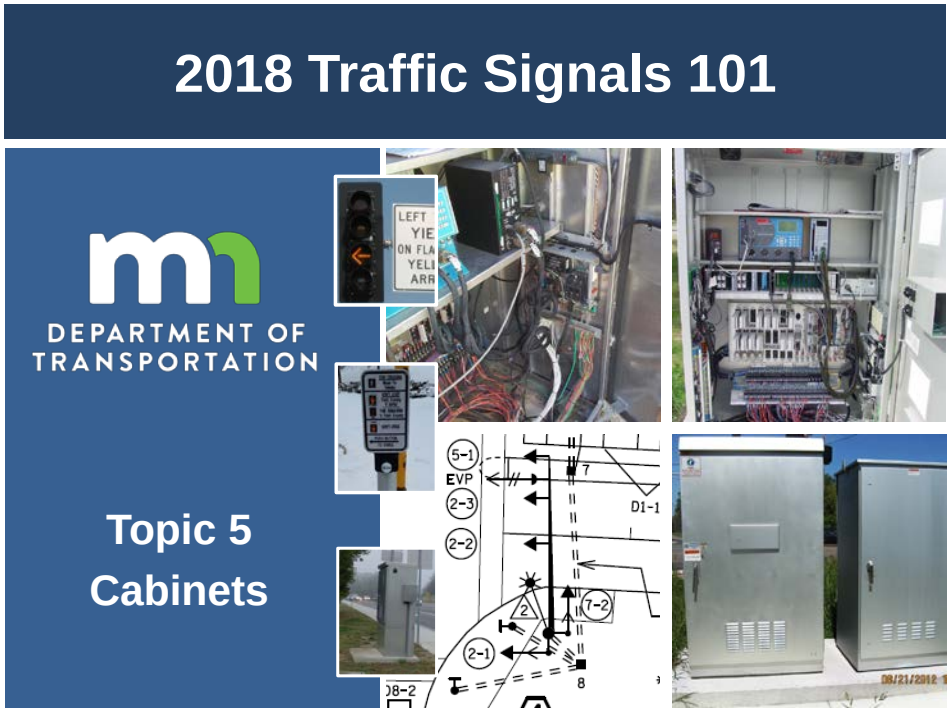
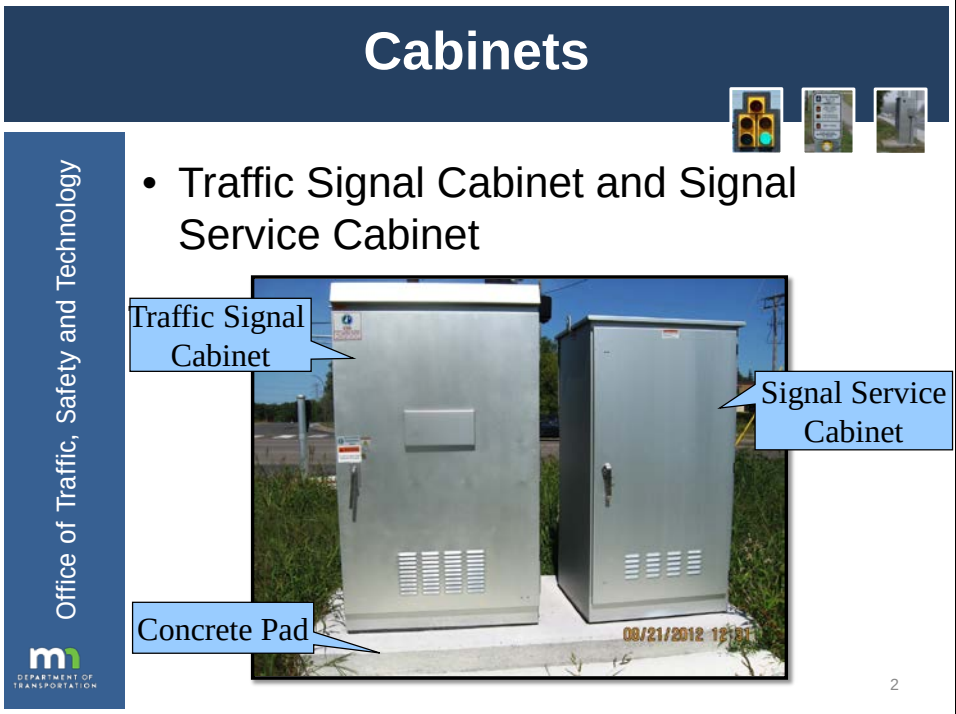
CCOCO1  CONDUCTOR COLOR CODE	CIR  CIRCLE FOR HEAD NUMBER	COCOCO  CONDUCTOR COLOR CODE	DETLL  DETECTOR LEFT LEFT	DETLR  DETECTOR LEFT RIGHT	DETRL  DETECTOR RIGHT LEFT	DETRR  DETECTOR RIGHT RIGHT	DOT  SPLICE DOT
DOT2  2 SPLICE DOTS	DOT3  3 SPLICE DOTS	DOT4  4 SPLICE DOTS	DOT5  5 SPLICE DOTS	DOT6  6 SPLICE DOTS	GRRD  GROUND ROD	HEX  HEXAGON FOR POLE OR PEDESTAL NUMBER	HH  HANDHOLE OR PULL BOX
HH2H  HANDHOLE FOR 2 DET HORIZONTAL	HH2V  HANDHOLE FOR 2 DET VERTICAL	HH3H  HANDHOLE FOR 3 DET HORIZONTAL	HH3V  HANDHOLE FOR 3 DET VERTICAL	HH4H  HANDHOLE FOR 4 DET HORIZONTAL	HH4V  HANDHOLE FOR 4 DET VERTICAL	INTL INTERCONNECT LEFT	INTR INTERCONNECT RIGHT
JB  JUNCTION BOX	LUML  LUMINAIRE LEFT	LUMR  LUMINAIRE RIGHT	SERV  SERVICE CABINET	SOP  SOURCE OF POWER WOOD POLE	WOODP  WOOD POLE	1CL  2-1/C LEFT	1CR  2-1/C RIGHT
12CCO  12/C#12 CONTINUOUS	12CL  12/C#12 LEFT	12CLC  12/C#12 LEFT CABINET	12CR  12/C#12 RIGHT	12CRC  12/C#12 RIGHT CABINET	2C14L 2/C#14 LEFT	2C14R 2/C#14 RIGHT	3CCON  3/C#12 CONTINUOUS
3CL 3/C#12 LEFT	3CLC 3/C#12 LEFT CABINET	3CR 3/C#12 RIGHT	3CRC 3/C#12 RIGHT CABINET	3C2LC 3/C#20 LEFT CABINET	3C2RC 3/C#20 RIGHT CABINET	3C20L 3/C#20 LEFT	3C20R 3/C#20 RIGHT
4C18L 4/C#18 LEFT	4C18R 4/C#18 RIGHT	5CCON 5/C#12 CONTINUOUS	5CL 5/C#12 LEFT	5CLC 5/C#12 LEFT CABINET	5CR 5/C#12 RIGHT	5CRC 5/C#12 RIGHT CABINET	95CR INP 5/C#12 RIGHT



TOPIC 5: CABINET





Traffic Signal Cabinet and Signal Service Cabinet

A typical installation of a Traffic Signal Cabinet and Signal Service Cabinet on a concrete pad.

Both cabinets meet Underwriters Laboratories (UL) standards.

Located adjacent to a signalized intersection.

Houses the controller which detects all vehicle and pedestrian activity and activates signals accordingly.

Cabinets

Office of Traffic, Safety and Technology

- Traffic Signal Cabinet and Signal Service Cabinets

Close-up of Signal Service Cabinet

3

Traffic Signal Cabinet and Signal Service Cabinets

Numerous Circuit Breakers, Switches, Cables, etc.

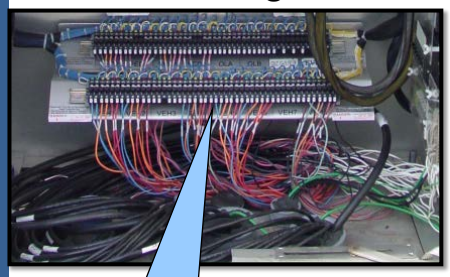
Furnishes power, and control to virtually all devices in, or adjacent to the intersection.

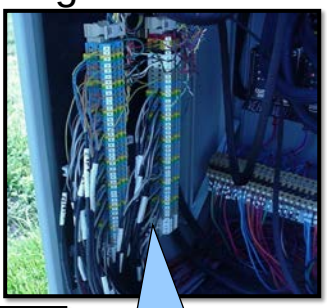
- Vehicle and Pedestrian indications
- Control equipment
- Convenience light and GFCI receptacle
- Street lighting

Cabinets

Office of Traffic, Safety and Technology

- Field Wiring in Traffic Signal Cabinet





Indication Hook-ups

Loop/PPB Hook-ups

Indication returns and grounds

Field Wiring in Traffic Signal Cabinet

All vehicle, pedestrian, and miscellaneous indications are connected to fuses and returned to neutral and ground busses.

All detector loops, and any other detection devices, are connected to Loop/Pedestrian Push-Button (PPB's) hook-up panel.

Cabinets

Office of Traffic, Safety and Technology

- Typical Traffic Signal Cabinets

5

Typical Traffic Signal Cabinets

Both sizes sit on the same bolt pattern.

Both current generation cabinets have identical panels and are wired identically.

The "P" size cabinet (60") has room enough only for basic control equipment.

Well-sized for business/downtown areas.

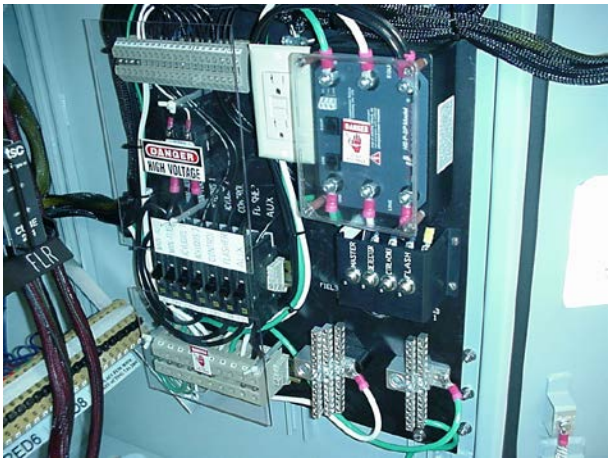
The "R" size cabinet (77") has room enough to add equipment for special equipment and operations.

- Autoscope
- Sonic Emergency Vehicle Preemption

Cabinets

Office of Traffic, Safety and Technology

- Power Panel



6

Power Panel

Electrical service from "Signal Service Cabinet" is connected here. (120VAC, single-phase, 60Hz)

Power Line protection is provided to help prevent damage from electrical overloading.

- Lightning
- Surges
- Nearby power-lines

Many neutral and ground wires connected here.

Provision for connecting test/maintenance equipment by furnishing a GFCI outlet.

- Drills
- Meters
- Power Line Monitors

NOTE: Some areas covered by plexi-glass to help prevent electrical shock.

Cabinets

Office of Traffic, Safety and Technology

- Cabinet Fans/Convenience Light Panel

7

Cabinet fans/Convenience Light Panel

Convenience light for cabinet maintenance.

1 of 2 ventilation fans.

Thermostat for control of ventilation fans.

Cabinets

Office of Traffic, Safety and Technology

- Detector Interface Panel

8

Detector Interface Panel

Wiring for ALL outputs of detection devices.

- 32 detector outputs in current cabinet configuration

Wiring for inputs to controller.

- 24 inputs in basic configuration for latest model

Wiring for inputs to, and outputs of controller to permit special functions.

- Detector reset
- Controller Reds & Greens
- Emergency Vehicle Preemption functions

Other special connections.

NOTE: Most special functions are currently accomplished via controller programming. In earlier controllers, these functions were accomplished with additional wiring.

Cabinets

Office of Traffic, Safety and Technology

- Detector Amplifier Rack

9

Detector Amplifier Rack

Provides physical housing for "plug-in type, rack-mountable" detector amplifier units.

Detector rack distributes AC and DC power to all detector units as needed.

All outputs are wired to the Detector Interface Panel.

All detector inputs are wired from the Loop/Pedestrian Push-Button hook-up panel.

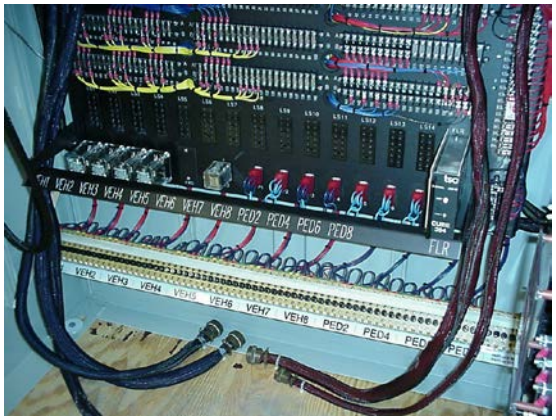
Various other inputs/outputs to accomplish proper, or enhanced detector operation.

Detector Power Supply (shown furthest left in picture) supplies DC power to Detector Rack.

Cabinets

Office of Traffic, Safety and Technology

- Controller Interface / Load-Switch / Flash Transfer Relay Panel



10

Controller Interface/Load-Switch/Flash Transfer Relay Panel

Controller Interface Panel

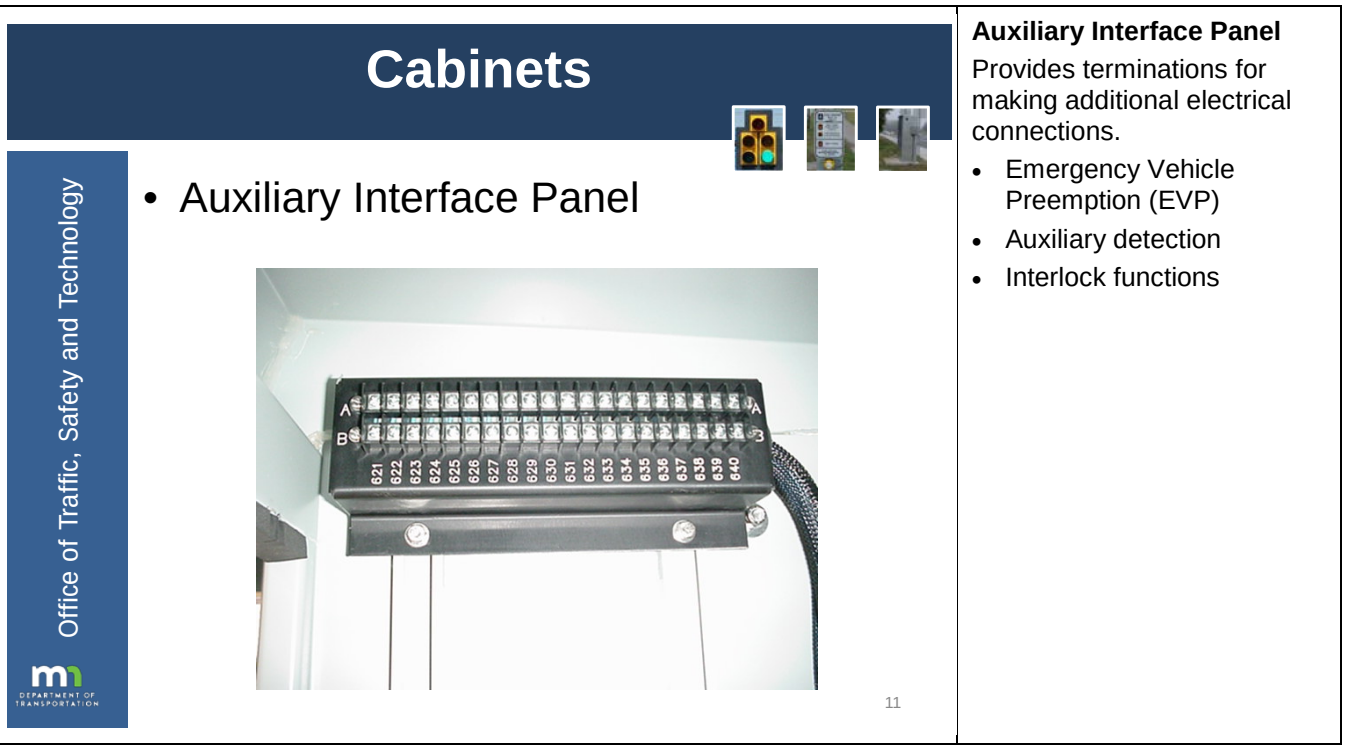
- ALL of the wires of the 3 NEMA controller connectors are terminated on the Controller Interface Panel. (177 connections)
- Many of the Conflict Monitor Unit (CMU) wires (approx. 49 of 81) are also terminated here.
- This is where signals input & output the controller. Most other assemblies and equipment are directly, or indirectly connected here.

Load-Switch Panel

- Load-switches are devices that convert the low-voltage D.C. outputs of the controller to High-voltage A.C. that power the indications in the intersection.
  - Opto-isolators in each load-switch help to protect the controller from high currents entering the controller.
    - Lightning
    - Over-voltage
    - Power-lines
- A Flasher is also located on the Load-Switch Panel. The flasher supplies power to the indications when the intersection is in the "Flash" mode.
  - Similar in basic operation to the Load-Switch
  - 2 alternating outputs, each 1 Hz, 50% duty cycle
- Flash Transfer Relays (FTR's) are also located on the Load-Switch Panel. These FTR's transfer indications between the load-switches and flasher.
  - FTR's usually control only the RED indications
    - Flash color (amber or red) determined by "Flash Plugs"

Weidmueller Fuse Panel

- All field indications are connected to these 80 indicating fuses.
  - These provide a relatively easy way of connecting field indications
  - Usually one wire for each individual indication
  - Neon lamp on each fuse location indicates if fuse is "blown"



Auxiliary Interface Panel

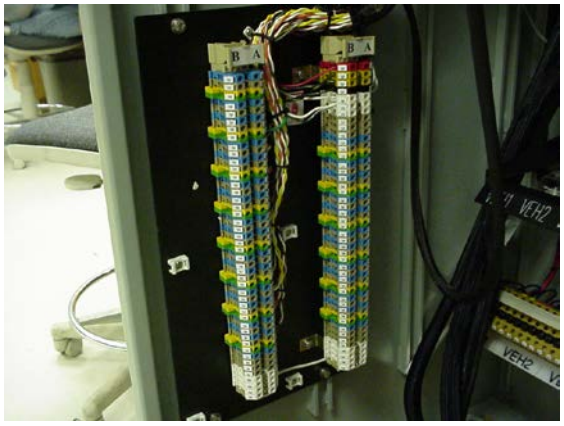
Provides terminations for making additional electrical connections.

- Emergency Vehicle Preemption (EVP)
- Auxiliary detection
- Interlock functions

Cabinets

Office of Traffic, Safety and Technology

- Loop/Pedestrian Push-Button Hook-up Panel



12

Loop/Pedestrian Push-Button hook-up Panel

Provides terminations for virtually ALL detection field wires.

- Vehicle detection types.
  - Loop
  - Microwave
  - Ultrasonic
  - Magnetometer
  - Video
- Pedestrian detection devices
  - Push-buttons
  - Optical sensors
- Emergency Vehicle Preemption
  - Optical
  - Sonic
- Railroad Preemption

Cabinets

Office of Traffic, Safety and Technology

- Auxiliary panel

13

Auxiliary panel

Control and Test switches

- Control Equipment Power switch
- Detector Power switch
- Master Controller Power switch
- Cabinet Lamp Power switch
- “Stop-Timing Override” switch
- Vehicle Test switches

Cabinets

Office of Traffic, Safety and Technology

- Police panel

14

Police Panel

AUTOMATIC - Normal "Stop-and-Go" and "Walk/Don't Walk" operation.

SIGNALS OFF – All traffic signal indications go dark.

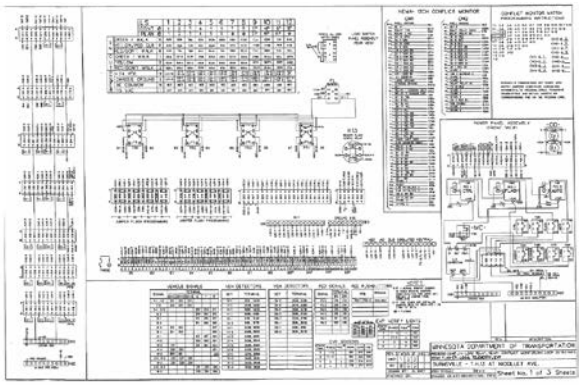
FLASH – Normally flashes Red/Red, pedestrian heads are off.

Note: If intersection has gone to flash due to automatic fault detection, it cannot be "reset" using this switch. If it's necessary to put the signal to "SIGNALS OFF" or "FLASH", it can be returned to "AUTOMATIC" operation. The operation will resume at the point at which the switch was moved from AUTOMATIC operation.

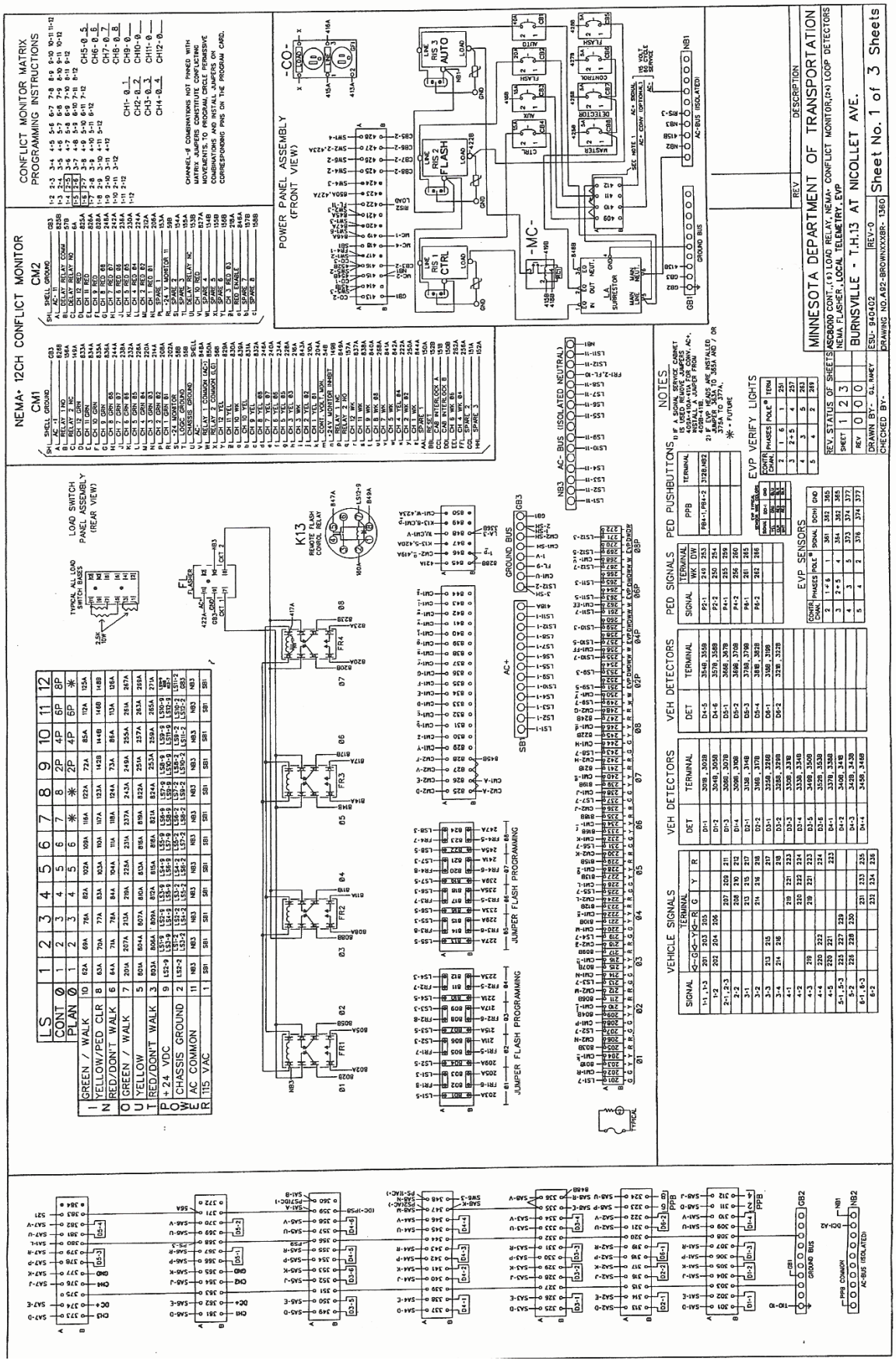
Cabinets

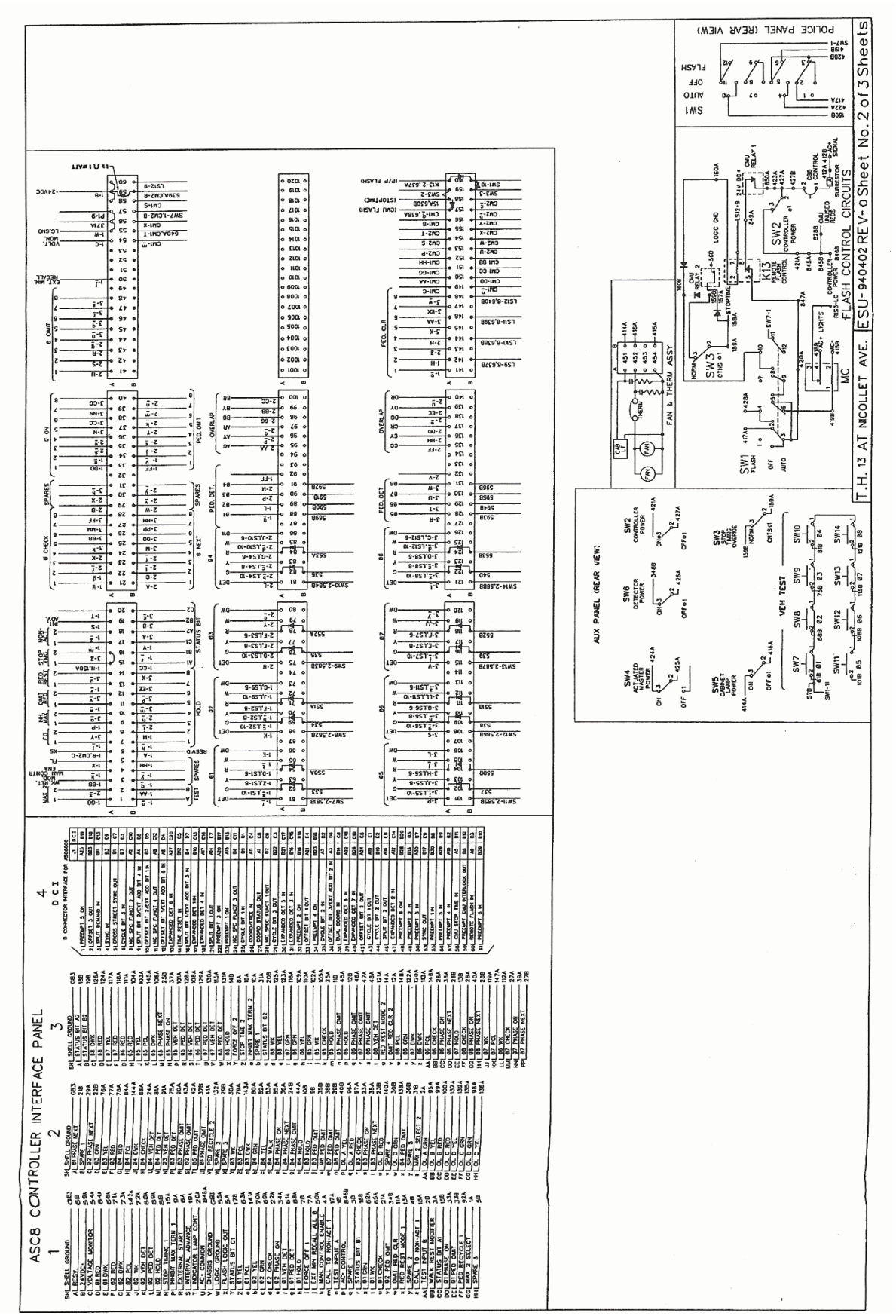
Office of Traffic, Safety and Technology

- HANDOUT - typical Cabinet Print (3 pages)



15

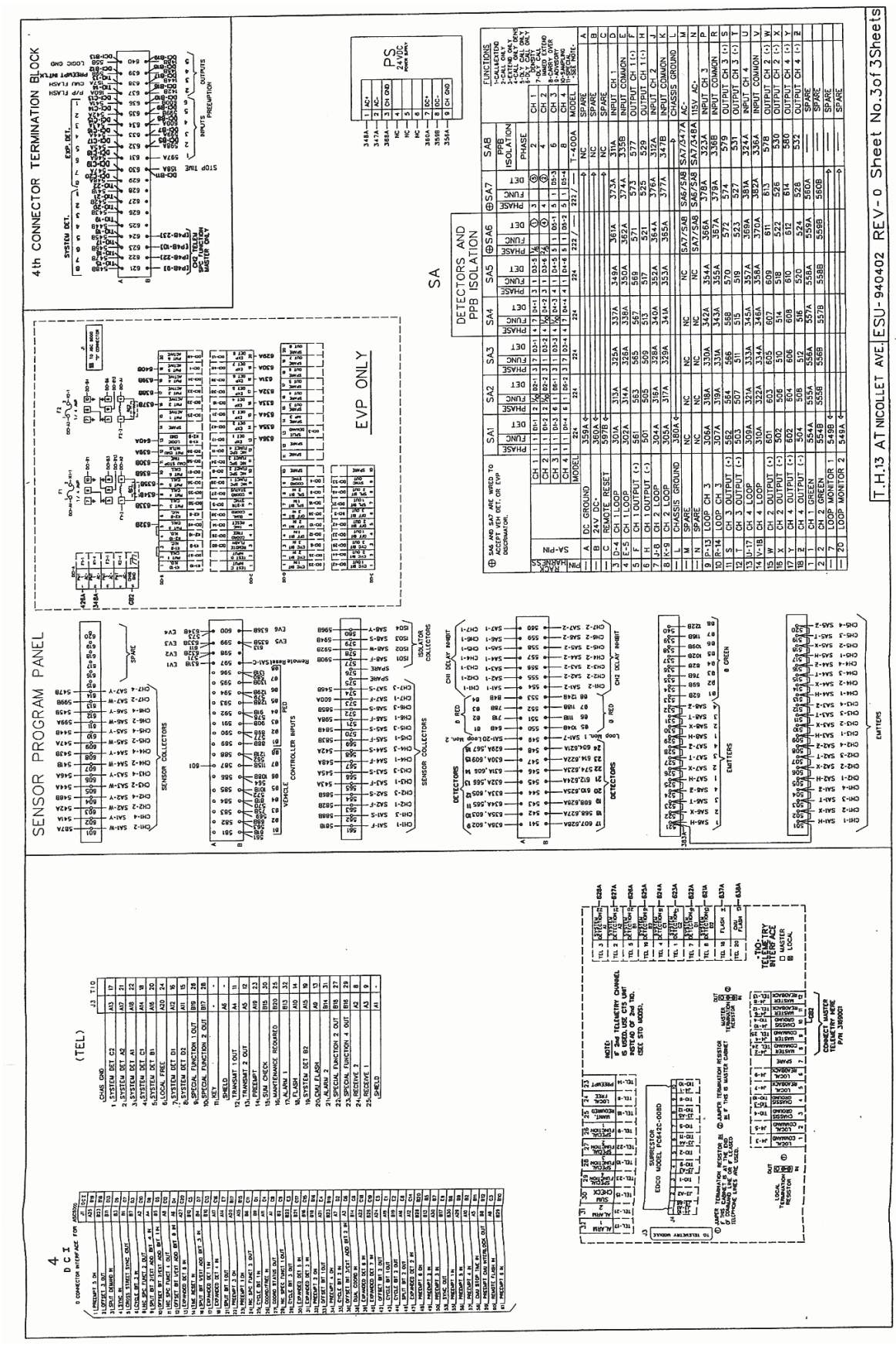




HANDOUT

HANDOUT

HANDOUT


SENSOR PROGRAM PANEL
EVP ONLY
SA
4th CONNECTOR TERMINATION BLOCK
DETECTORS AND PPB ISOLATION
T.H.13 AT NICOLLET AVE. ESU-940402 REV-0 Sheet No.3of 3Sheets

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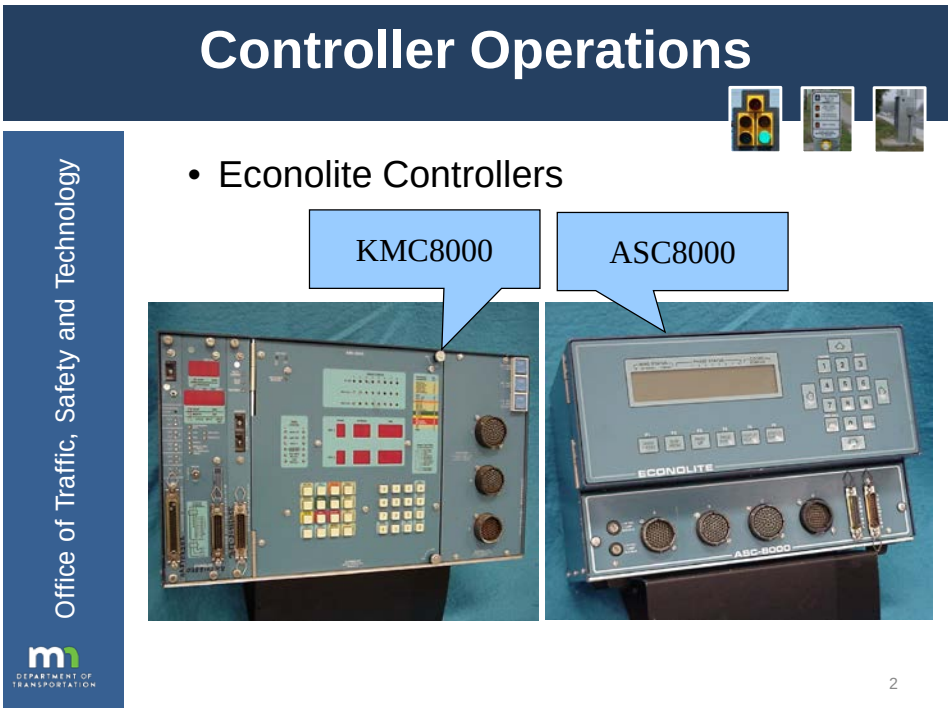
TOPIC 6: CONTROLLER OPERATIONS

In this topic you will be introduced to traffic signal controller operations.



KMC8000

1. Oldest of the three controllers displayed here.
2. The most rugged of the three.
3. The most difficult to install.
4. Least capable of the three without extensive external wiring/equipment.
   - More external connections.
   - More complicated wiring.

B. ASC8000

1. Newer, and less rugged as the previous controller mentioned.
2. Less wiring with less difficulty.
3. Capabilities increased greatly.

Controller Operations

Office of Traffic, Safety and Technology

- Econolite Controllers

ASC2

ASC2S

3

C. ASC2

1. Great capability with least external connections.

D. ASC2S

1. Same as ASC2 except for surface mount technology.
2. Surface mount technology results in small-size, light-weight. (≈7x9x15 inches/≈8½lbs.)

Controller Operations

Office of Traffic, Safety and Technology

- Econolite Controllers

KMC10,000

ASC2M

4

E. ASC2M & KMC10,000

Controller Operations

Office of Traffic, Safety and Technology

ASC3

Cobalt

Source: www.econolite.com

Eagle 2070 Product Sheet

Naztec 2070 Product Sheet

5

F. ASC3 controller

1. Great capability.

2. Fully compliant with NEMA TS2.

G. Cobalt controller

1. Newest, with great flexibility

2. Touch screen

Controller Operations

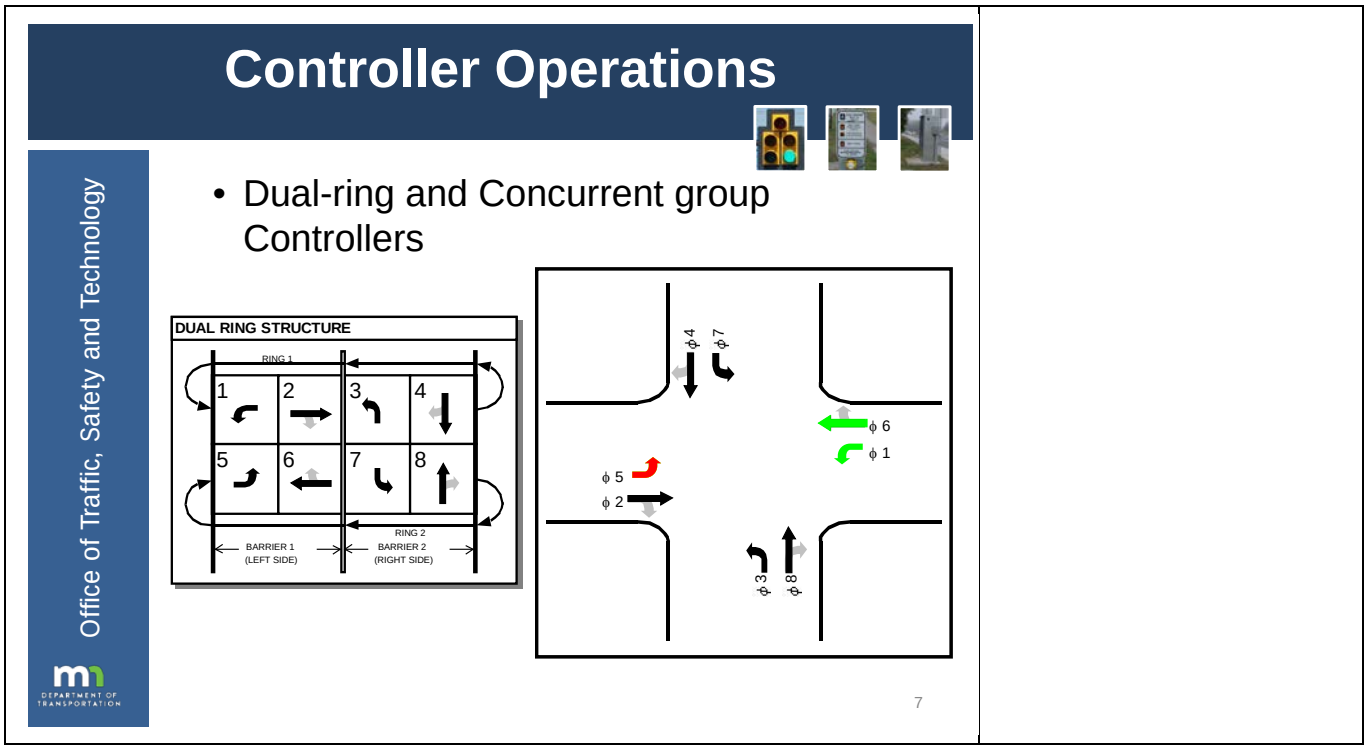
Office of Traffic, Safety and Technology

- NEMA (National Electrical Manufacturers Association) Controllers
  - NEMA's involvement in controller design helped greatly to simplify installations
  - Standardization of A, B, C (1, 2, 3) connectors
  - Operating limits standardized
  - Standardization of timed intervals
    - Passage time
    - Maximum green time
    - Gap reduction
    - Walk & Ped Clearance
    - Many more intervals with proper operation dictated by NEMA

6

NEMA Controllers

1. Standardized connectors
   - Standard "pin-outs".
   - Standard Input/Output (I/O) names.
   - Connectors physical identical/interchangeable.
2. Operating limits
   - Operating temperature range. -30°F to 165°F.
   - Humidity range. >95% @40°F to 110°F.
   - Operating voltage. 89 to 135 VAC.
   - The above three specifications are but a few of many. Many other parameters have contributed to a better product.



Dual-ring and concurrent group controllers.

A. A dual-ring controller operates similar to TWO separate controllers.

- Ring 1 contains phases ∅1, ∅2, ∅3, ∅4.
- Ring 2 contains phases ∅5, ∅6, ∅7, ∅8.
- No more than one phase from either ring can time at any given time.

B. An 8∅ (eight-phase) usually has two CONCURRENT groups.

- Concurrent Group 1 contains phases ∅1, ∅2, ∅5, ∅6.
- Concurrent Group 2 contains phases ∅3, ∅4, ∅7, ∅8.
- Phases from one group cannot time with phases of the other group.

C. Combining two rings with two concurrent gives the following:

- ∅1 or ∅2 allowed to time with ∅5 or ∅6 and vice-versa.
- ∅3 or ∅4 allowed to time with ∅7 or ∅8 and vice-versa.

D. Barriers.

- Phase(s) must terminate their timing and cross the “BARRIERS” together.

E. Exceptions.

- The model of the current discussion has been about a “dual-ring, two concurrent group, eight-phase controller configuration.
- IT CAN ALL BE CHANGED, within limits, TO PERFORM SPECIAL OPERATIONS.

Controller Operations

Office of Traffic, Safety and Technology

- Conflict Monitor Unit (CMU)

8

Conflict Monitor Unit. (CMU)

A. When the CMU recognizes a "fault", it will put the intersection to FLASH.

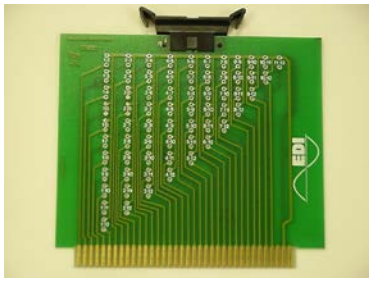
B. Not an integral part of the controller.

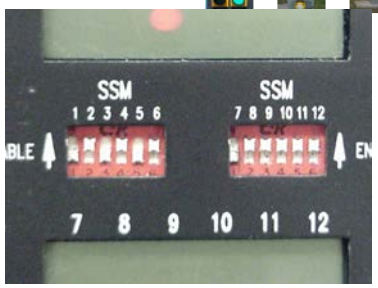
C. Monitors condition of the controller.

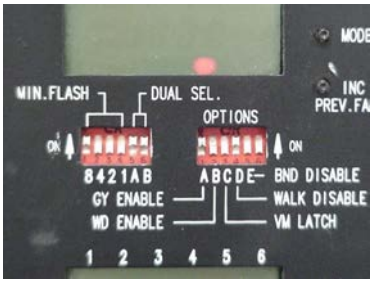
- Internal controller voltages monitored.
- Certain controller programming monitored.

Controller Operations

Office of Traffic, Safety and Technology







D. Monitors field indications <u>AT THE POINT THE CIRCUITS LEAVE THE CABINET</u>.

Checks for:

- Conflicts.
- Red failure.
- Dual indication.

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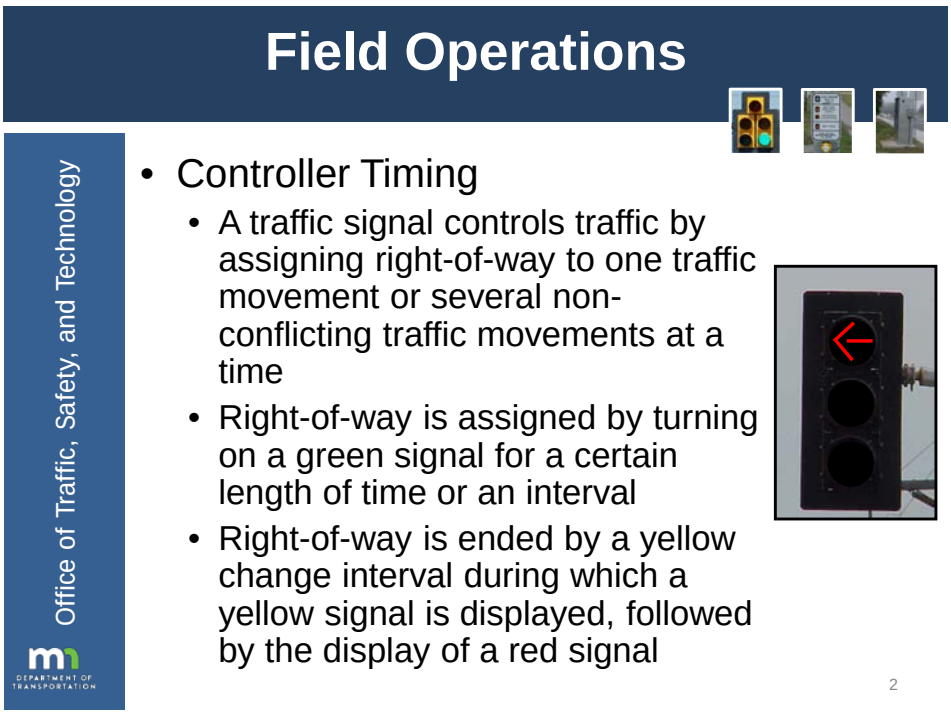
TOPIC 7: FIELD OPERATIONS

In this topic, you will be introduced to the operation of signals in the field. This includes controller elements such as cycle length and phases; pedestrian timing requirements; pre-timed and actuated signal control; and system control.



The objective of traffic signal timing is to assign the right-of-way to alternating traffic movements in such a manner to minimize the average delay to any group of vehicles or pedestrians and reduce the probability of accident producing conflicts.

Field Operations

Office of Traffic, Safety, and Technology

- Cycle Length
  - The cycle length is the total time to complete one sequence of signalization around an intersection
  - In an actuated controller unit, a complete cycle is dependent on the presence of calls on all phases
  - In a pre-timed controller unit it is a complete sequence of signal indications
  - In a fully actuated signal (defined later), the cycle length varies
  - The cycle length is fixed in a coordinated or pre-timed signal

Animation | Synchro

Short cycle lengths typically yield the best performance in terms of providing the lowest overall average delay provided the capacity of the cycle to pass vehicles is not exceeded. ***The cycle length, however, must allow adequate time for vehicular and pedestrian movements***. Longer cycles are used during peak periods to provide more green time for the major street, to permit larger platoons in the peak direction, and/or to reduce the number of starting delays.

Field Operations

Office of Traffic, Safety, and Technology

- Phase Change Interval
  - The phase change interval timing (Yellow) advises drivers that their phase has expired and they should:
    - come to a safe stop prior to the stop line, or;
    - proceed through the intersection if they are too near the intersection to stop
  - Intersection Clearance Interval (All-Red)
    - The Intersection Clearance Interval will provide a vehicle enough time at the end of yellow to clear before the next green is displayed

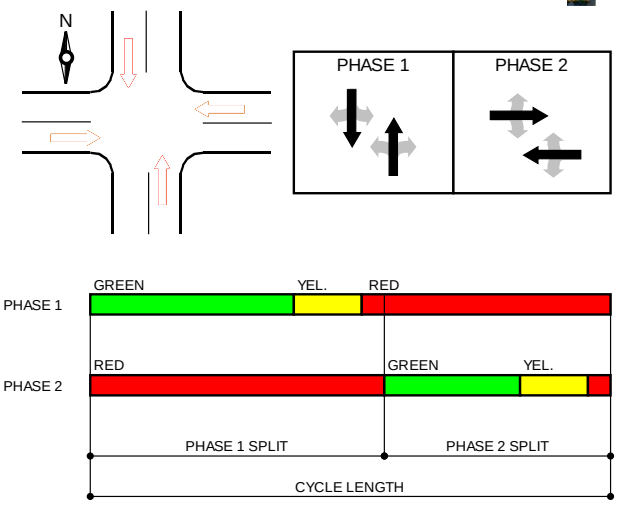
4

The MN MUTCD states that the exclusive function of the steady yellow interval shall be to warn traffic of an impending change of right-of-way assignment. The yellow vehicle change interval should have a range of approximately 3 to 6 seconds. Generally the longer intervals are appropriate to higher approach speeds. The yellow vehicle change interval should be followed by a short all-way red clearance interval, of sufficient duration to permit the intersection to clear before cross traffic is released.

Minnesota Traffic Laws state that vehicular traffic facing a yellow indication are warned that the related green movement is being terminated or that the red indication will be exhibited immediately thereafter when vehicular traffic shall not enter the intersection.

Field Operations

Office of Traffic, Safety, and Technology



5

The figure at the left shows the timing operation for a basic two-phase or two-traffic movement pre-timed controller. Note that at the end of phase 1 and phase 2 yellow, there is a short all-red clearance interval.

Field Operations

Office of Traffic, Safety, and Technology

- Pedestrian Timing
  - Walk
    - The MN MUTCD states, "the WALK interval should be at least 4 to 7 seconds in length so that pedestrians will have adequate opportunity to leave the curb before the clearance interval is shown"
    - If pedestrian volumes and characteristics do not require a 7-second walk interval, walk intervals as short as 4 seconds may be used.
  - Flashing Don't Walk
    - flashing DON'T WALK = D/R

6

The *flashing* DON'T WALK interval is determined by the following formula:

flashing DON'T WALK = D/R

D = Distance from the near curb or shoulder to at least the center of the farthest traveled lane.

R = Walking rate of 3.5 ft/sec assumed walking rate unless special conditions (school kids, elderly or handicapped) require a slower walking rate.

See topic 9 on pedestrians for further details.

Field Operations

Office of Traffic, Safety, and Technology

- Pre-timed signal control
  - Under these conditions, the signal assigns right-of-way at an intersection according to a predetermined schedule
  - The sequence of right-of-way (phases), and the length of the time interval for each signal indication in the cycle is fixed, based on historic traffic patterns

Animation 7

No recognition is given to the current traffic demand on the intersection approaches unless detectors are used. The major elements of pre-timed control are (1) fixed cycle length, (2) fixed phase length, and (3) number and sequence of phases.

Advantages to pre-timed control include:

Simplicity of equipment provides relatively easy servicing and maintenance.

Can be coordinated to provide continuous flow of traffic at a given speed along a particular route, thus providing positive speed control.

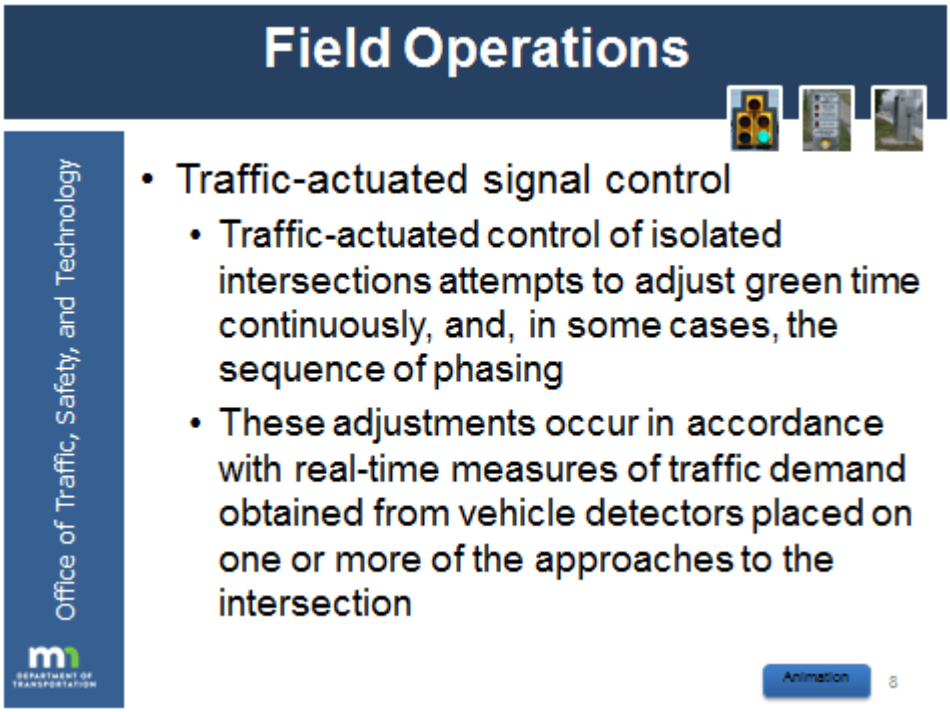
Timing is easily adjusted in the field.

Under certain conditions can be programmed to handle peak conditions.

Disadvantages to pre-timed control include:

Do not recognize or accommodate short-term fluctuations in traffic.

Can cause excessive delay to vehicles and pedestrians during off-peak periods.



The full range of actuated control capabilities depends on the type of equipment employed and the operational requirements.

Advantages to actuated signals include:

Usually reduce delay (if properly timed).

Adaptable to short-term fluctuations in traffic flow.

Usually increase capacity (by continually reapportioning green time).

Provide continuous operation under low volume conditions as an added safety feature, when pre-timed signals may be put on flashing operation to prevent excessive delay.

Especially effective at multiple phase intersections.

Disadvantages to actuated control include:

The cost of an actuated installation is substantially higher than the cost of a pre-timed installation.

Actuated controllers and detectors are much more complicated than pre-timed signal controllers, increasing maintenance and inspection skill requirements and costs.

Detectors are costly to install and require careful inspection and maintenance to ensure proper operations.

Field Operations

Office of Traffic, Safety, and Technology

- Traffic-Actuated Control
  - Full Actuated Control
    - In full actuated control, all signal phases are actuated and all signalized movements require detection
  - Many MnDOT applications require full-actuated density operation (refer to the Traffic Signal Timing and Coordination Manual)

9

Traffic actuated signal control can further be broken into the following categories:

Semi-Actuated

Full Actuated Control

Field Operations

Office of Traffic, Safety, and Technology

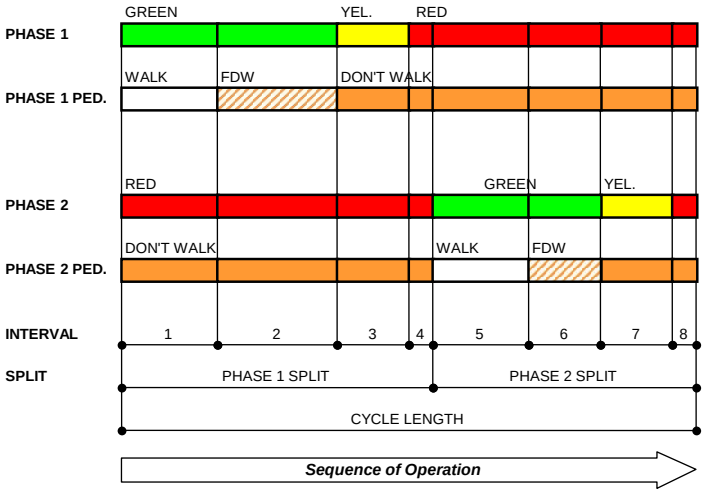
- Traffic Signal Phasing
  - A traffic signal phase, or split, is the part of the cycle given to an individual movement, or combination of non-conflicting movements during one or more intervals
  - An interval is a portion of the cycle during which the signal indications do not change

10

The predetermined order of phases is the sequence of operation. This order is fixed in a pre-timed controller, and under certain circumstances, may be variable with an actuated controller.

Field Operations

Office of Traffic, Safety, and Technology



11

For the figure to the left, there are eight intervals where the signal indications do not change. Notice that intervals 4 and 8 are all red periods (interval 4 is the phase 1 all red and interval 8 is the phase 2 all red). The phase 1 split is made up of intervals 1 through 4 and the phase 2 split is made up of intervals 5 through 8. The sum of split 1 and 2 is the cycle length.

Field Operations

Office of Traffic, Safety, and Technology

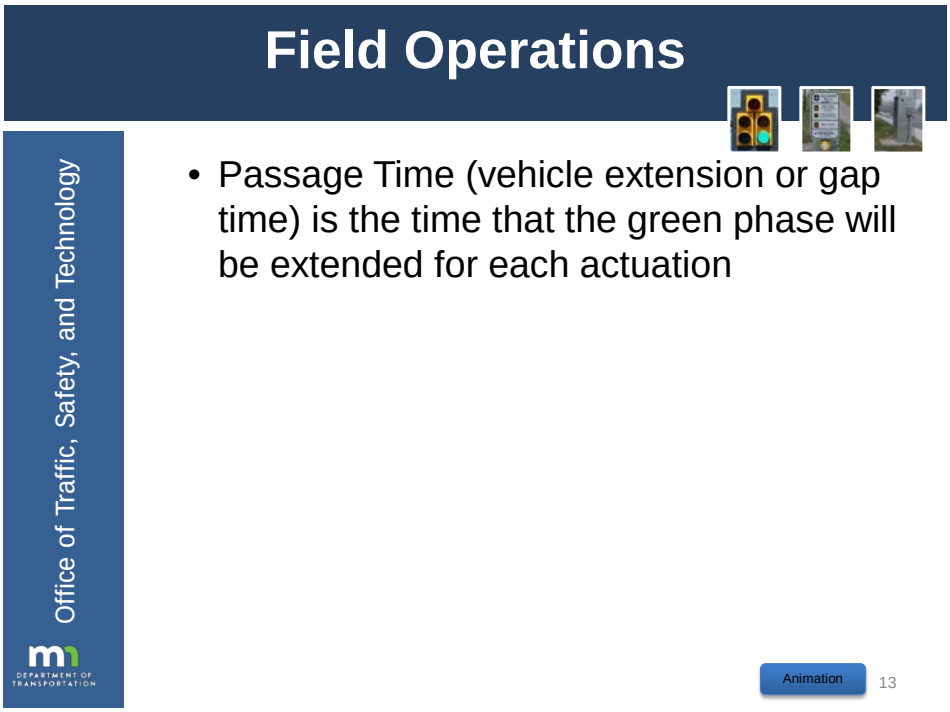
- Actuated Controller Phase Operations
  - Minimum Green Interval is the shortest green time of a phase
  - A minimum green time setting will accommodate the lowest expected number of vehicles that arrive per cycle
  - It also allows approaching vehicles a chance to reach detectors

Animation

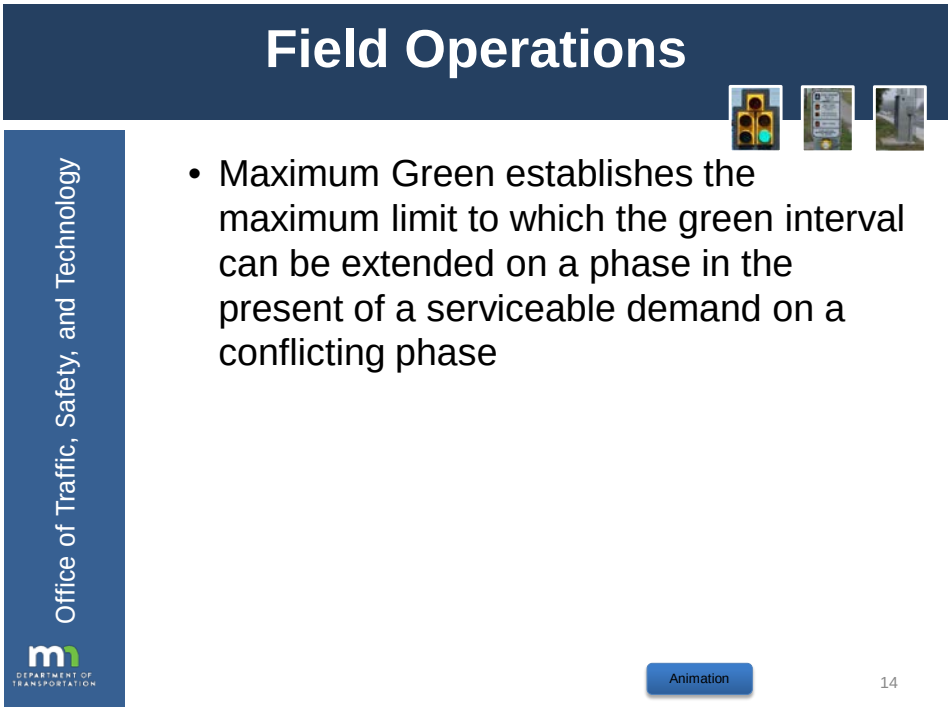
12

Definition of the **minimum green** interval for an actuated controller.

There must be a minimum green time so that stopped vehicles have enough time to get started and partially cross the intersection before the clearance interval appears.



Passage time (vehicle extension or gap time) is typically set as the time it takes to travel from the vehicle detector to the stop line at the travel speed of the roadway for pulse loops or the average acceptable headway between vehicles for presence loops located close to the stop line.



Most controllers used by Mn/DOT can have two or more maximum green times programmed. The second maximum time can put into effect by time clock.

Field Operations

Office of Traffic, Safety, and Technology

- Recall
  - Recall to Minimum: When active and in the absence of a vehicle call on the phase, a temporary call to service the minimum initial time will be placed on the phase
  - Recall to Maximum: With the maximum vehicle recall active a constant vehicle call will be placed on the phase
  - Recall to Pedestrian: This feature provides vehicle green and pedestrian walk and clearance intervals

15

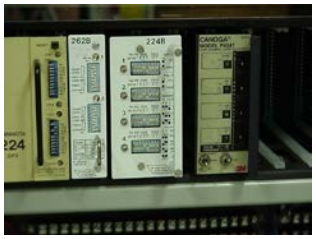
In the absence of an actuation, a controller unit will normally rest on the current phase being serviced. A recall will force the controller to return to a particular phase's green interval, even with no demand.

An actuation is the operative response of any type of detector (call).

Field Operations

Office of Traffic, Safety, and Technology

- Vehicle Detection

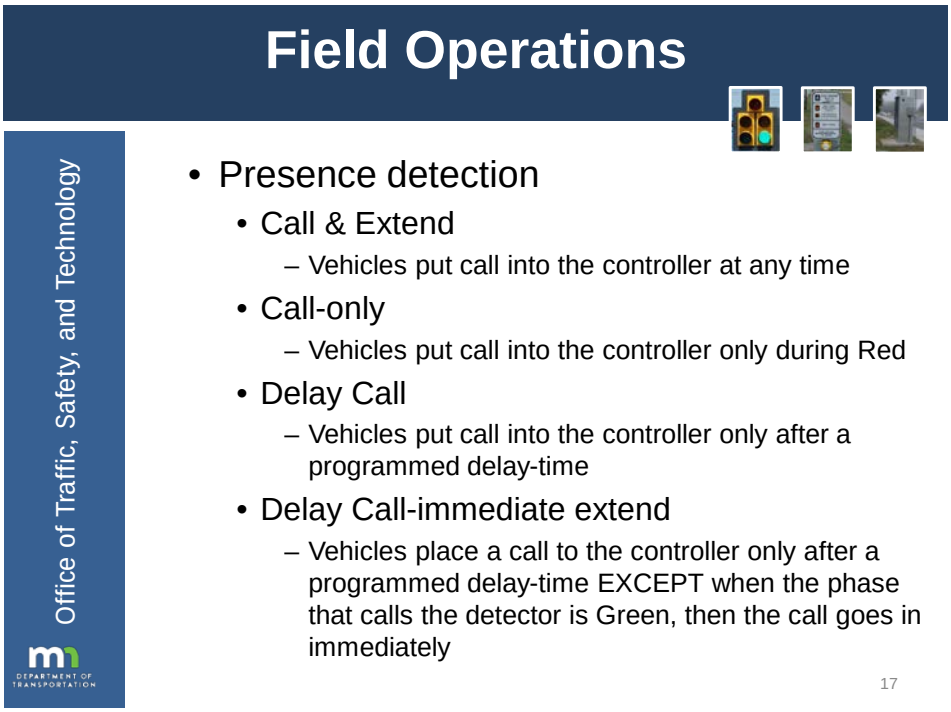



16

One of the advantages to actuated control is the ability to adjust timing parameters based on actual vehicle or pedestrian demand. Since this vehicle or pedestrian demand varies at different times of the day, a detector is placed in the path of approaching vehicles or at a convenient location for the use of pedestrians.

The actual operation of the signal is highly dependent on the operation of these detectors.

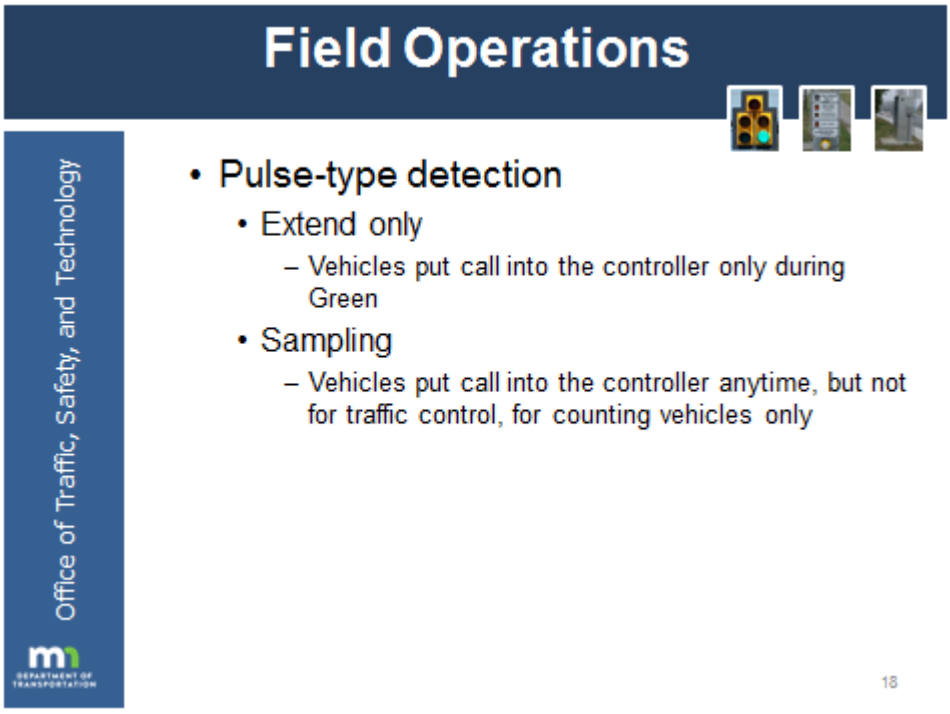
The pictures at the left show typical detector units in the controller cabinet. The detectors used in the field will be discussed in the following slides.



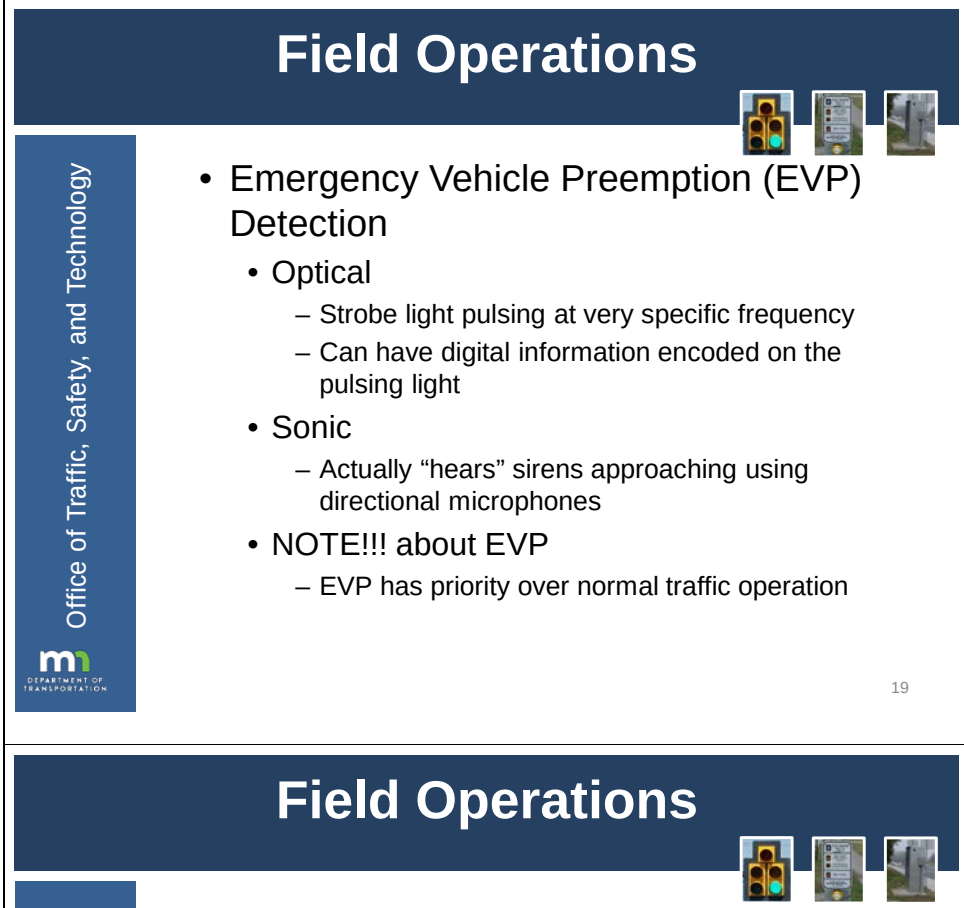
A presence detector has the ability to sense that a vehicle, whether moving or stopped, has appeared in its zone of detection.

A call is a registration of a demand for the right-of-way by traffic at a controller unit.

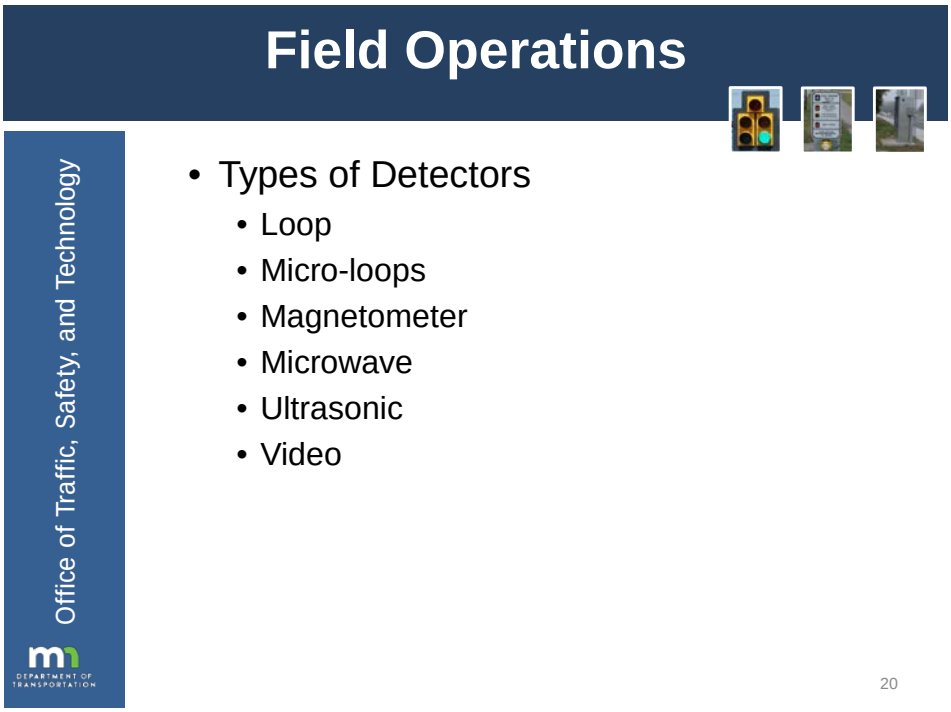
An extension detector is one that is arranged to register an actuation at the controller unit only during the green interval for that approach so as to extend the green time of the actuating vehicles.



Pulse mode detection is a mode of operation where the detector produces a short output pulse when detection occurs.



An EVP detector is a device that preempts a traffic signal controller. See topic 12 for further details.



A loop detector is the most common detector type. It is a loop of wire imbedded in the pavement carrying a small electrical current. When a large mass of metal passes over the loop, it senses a change in inductance of its inductive loop sensor by the passage or presence of a vehicle near the sensor.

A magnetometer measures the difference in the level of the earth's magnetic forces caused by the passage or presence of a vehicle near its sensor.

A microwave radar detector is a detector that is capable of sensing the passage of a vehicle through its field of emitted microwave energy.

An ultrasonic detector is capable of sensing the passage or presence of a vehicle through its field of emitted ultrasonic energy.

A video detector responds the video image or changes in the video image of a vehicle.

Field Operations

Office of Traffic, Safety, and Technology

- Coordinated Systems
  - A coordinated system is a series of signalized intersections that are designed to interact as a system. Reasons for coordinating include:
    - To move traffic through a series of intersections
    - To reduce delay
    - Move vehicles in a grid system
    - To help reduce gridlock for closely spaced intersections

21

The system concept as related to traffic signal control includes the methods, equipment, and techniques required coordinating traffic flow along an arterial or throughout an area.

Field Operations

Office of Traffic, Safety, and Technology

- System Objective
  - The major objective of a traffic control system is to permit continuous movement and/or minimize delay along an arterial or throughout a network of major streets
  - In the system, a timing plan is defined by a combination of control parameters for one or more intersections based upon an analysis of demand

22

The major objective of a traffic control system is to permit continuous movement and/or minimize delay along an arterial or throughout a network of major streets. This involves the selection, implementation, and monitoring of the most appropriate operational plan. Basically, a traffic signal system provides the appropriate and necessary timing plans for each intersection in terms of individual needs as well as the combined needs of a series of intersections.

Field Operations

Office of Traffic, Safety, and Technology

- Timing plans for a system consists of:
  - A System Cycle. A specific cycle length is imposed throughout the system covered by the timing plan
  - Split. Each movement in the intersection has a defined split
  - Offset. The offset is the relationship of the beginning of the main street green at this intersection to a master system base time
  - Offset should be expressed in seconds
  - The difference in offset between intersections along a street defines the speed at which traffic can travel without stopping

Animation

23

Field Operations

Office of Traffic, Safety, and Technology

- Types of Traffic Signal Control Systems
  - Time of Day (TOD) Time Based System
    - Non-interconnected System. The offset relationship is maintained by relying on the clocks in the local controllers
    - Interconnected System. Local intersections are physically interconnected to ensure coordinated operation
  - Traffic Responsive System
    - Volume levels determine which of a number of available cycle lengths is selected, and volume differential determines offset (i.e., inbound, outbound, or average)

24

Handout

Excerpts from the Traffic Signal Timing and Coordination Manual

For the latest version of this manual, please visit:

www.dot.state.mn.us/trafficeng/publ/index.html

3.3 Signal Timing and Phasing

Controller Unit Timing

A traffic signal controls traffic by assigning right-of-way to one traffic movement or several non-conflicting traffic movements at a time. Right-of-way is assigned by turning on a green signal for a certain length of time or an interval. Right-of-way is ended by a yellow change interval during which a yellow signal is displayed, followed by the display of a red signal. The device that times these intervals and switches the signal lamps is called a controller unit. This section will cover the operation of controller units and the various features and characteristics of the types currently available.

Control Concepts

Traffic control concepts for isolated intersections basically fall into two basic categories, pre-timed and traffic-actuated.

Pre-timed signal control

Under these conditions, the signal assigns right-of-way at an intersection according to a predetermined schedule. The sequence of right-of-way (phases), and the length of the time interval for each signal indication in the cycle is fixed. No recognition is given to the current traffic demand on the intersection approaches unless detectors are used. The major elements of pre-timed control are (1) fixed cycle length, (2) fixed phase length, and (3) number and sequence of phases.

Advantages to pre-timed control include:

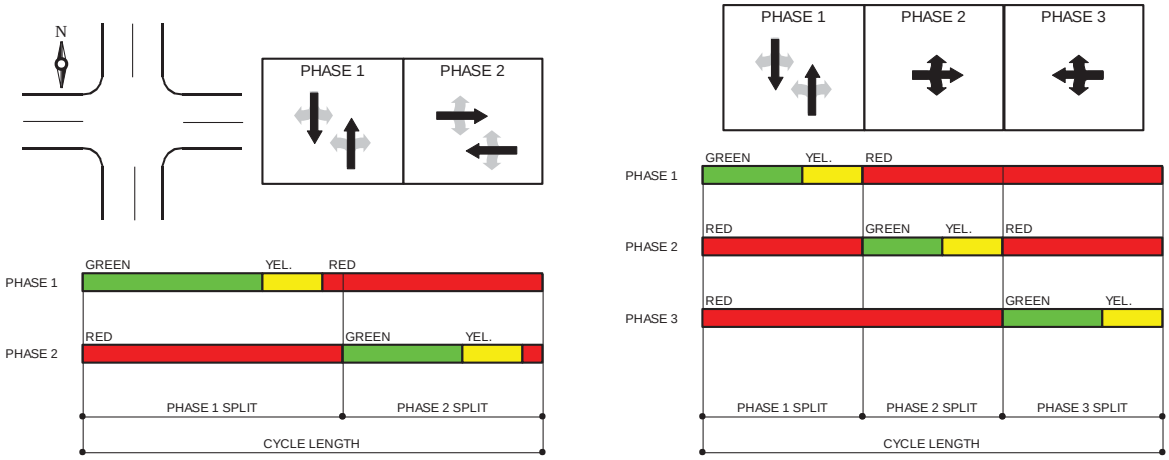
- ✓ Simplicity of equipment provides relatively easy servicing and maintenance.
- ✓ Can be coordinated to provide continuous flow of traffic at a given speed along a particular route, thus providing positive speed control.
- ✓ Timing is easily adjusted in the field.
- ✓ Under certain conditions can be programmed to handle peak conditions.

Disadvantages to pre-timed control include:

- ✓ Do not recognize or accommodate short-term fluctuations in traffic.
- ✓ Can cause excessive delay to vehicles and pedestrians during off-peak periods.

The left side of the following figure shows the timing operation for a basic two-phase or two-traffic movement pre-timed controller unit. The right side of the figure shows the timing operation for a three phase pre-timed controller unit. For the pre-timed controller, the length of time for each phase is fixed.

Exhibit 3-1 Basic Two-Phase Pre-timed Signal Operation



Traffic-actuated signal control

Traffic-actuated control attempts to adjust green time continuously, and, in some cases, the sequence of phasing. These adjustments occur in accordance with real-time measures of traffic demand obtained from vehicle detectors placed on one or more of the approaches to the intersection. The full range of actuated control capabilities depends on the type of equipment employed and the operational requirements.

Advantages to actuated signals include:

- ✓ Usually reduce delay (if properly timed).
- ✓ Adaptable to short-term fluctuations in traffic flow.
- ✓ Usually increase capacity (by continually reapportioning green time).
- ✓ Provide continuous operation under low volume conditions as an added safety feature, when pre-timed signals may be put on flashing operation to prevent excessive delay.
- ✓ Especially effective at multiple phase intersections.

Disadvantages to actuated control include:

- ✓ The cost of an actuated installation is higher than the cost of a pre-timed installation.
- ✓ Actuated controllers and detectors are much more complicated than pre-timed signal controllers, increasing maintenance and inspection skill requirements and costs.
- ✓ Detectors are costly to install and require careful inspection and maintenance to ensure proper operations.

Traffic actuated signal control can further be broken into the following categories:

Semi-Actuated Control. In semi-actuated control, the major movement receives green unless there is a conflicting call on a minor movement phase. The minor phases include any protected left-turn phases or side street through phases. Detectors are needed for each minor movement. Detectors may be used on the major movement if dilemma zone protection is desired.

In semi-actuated coordinated systems (referred to as Actuated Coordinated in Synchro), the major movement is the "sync" phase. Minor movement phases are served only after the sync phase yield point and are terminated on or before their respective force off points. These points occur at the same point in time during the background signal cycle and ensure that the major road phase will be coordinated with adjacent signal controllers.

In semi-actuated non-coordinated systems, the major movement phase is placed on minimum (or maximum) recall. The major movement rests in green until a conflicting call is placed. The conflicting phase is serviced as soon as a gap-out or max-out occurs on the major phase. Immediately after the yellow is presented to the major phase, a call is placed by the controller for the major phase, regardless of whether or not a major phase vehicle is present.

Full Actuated Control. In full actuated control, all signal phases are actuated and all signalized movements require detection. Generally used at isolated intersections; however, can also be used at high-demand intersections in coordinated systems.

Volume-density operation can be considered to be a more advanced form of full-actuated control. It has the ability to calculate the duration of minimum green based on actual demand (calls on red) and the ability to reduce the maximum allowable time between calls from passage time down to minimum gap. Reducing the allowable time between calls below the passage time will improve efficiency by being better able to detect the end of queued flow.

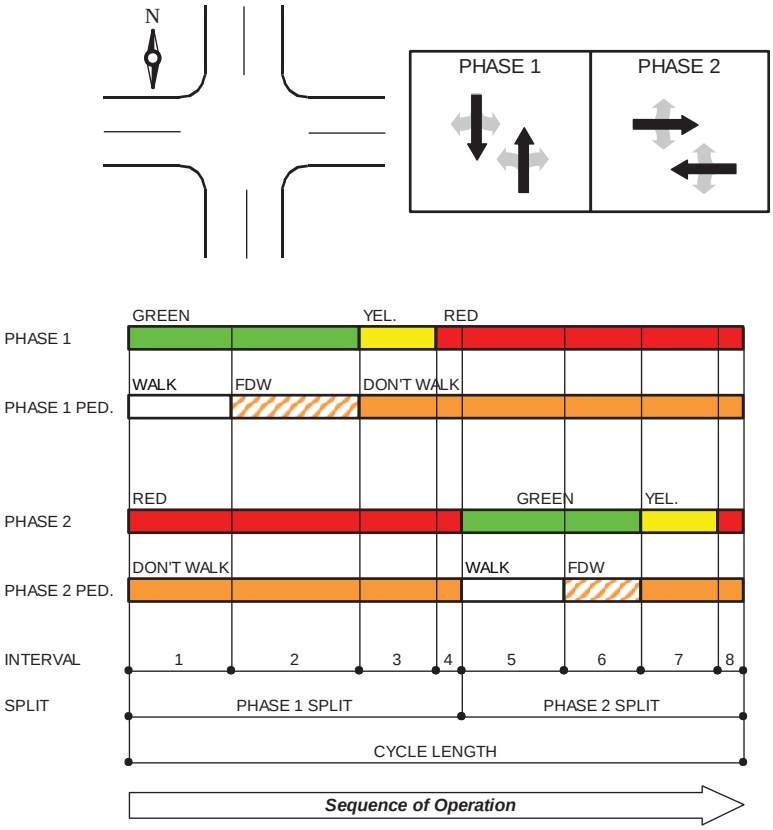
Traffic Signal Phasing

A traffic **signal phase**, or **split**, is the part of the cycle given to an individual movement, or combination of non-conflicting movements during one or more intervals. An **interval** is a portion of the cycle during which the signal indications do not change.

The predetermined order of phases is the sequence of operation. This order is fixed in a pre-timed controller, and under certain circumstances, may be variable with an actuated controller.

Consider **Exhibit 3-2** for an example two-phase (single ring) signal with pedestrian timing. In the figure, there are eight intervals where the signal indications do not change. Notice that intervals 4 and 8 are all red periods (interval 4 is the phase 1 all red and interval 8 is the phase 2 all red). The phase 1 split is made up of intervals 1 through 4 and the phase 2 split is made up of intervals 5 through 8. The sum of split 1 and 2 is the cycle length.

Exhibit 3-2 Traffic Signal Phasing



Ring and Barrier Structure

Ring

A ring is a term that is used to describe a series of conflicting phases that occur in an established order. A ring may be a single ring, dual ring, or multi-ring and is described in detail below. A good understanding of the ring structure is a good way to understand the operation of multiphase controllers.

Barrier

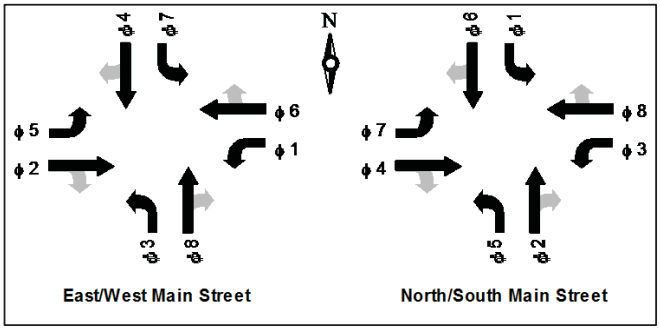
A barrier (compatibility line) is a reference point in the preferred sequence of a multi-ring controller unit at which all rings are interlocked. Barriers assure there will be no concurrent selection and timing of conflicting phases for traffic movements in different rings. All rings cross the barrier simultaneously to select and time phases on the other side.

Phase Numbers

Phase numbers are the labels assigned to the individual movements around the intersection. For an eight phase dual ring controller (see definition of dual ring), it is common to assign the main street through movements as phases 2 and 6. Also, it is common to use odd numbers for left turn signals and the even numbers for through signals. A rule of thumb is that the sum of the through movement and the adjacent left turn is equal to seven or eleven.

Exhibit 3-3 shows a typical phase numbering scheme for an east/west arterial and a north/south arterial.

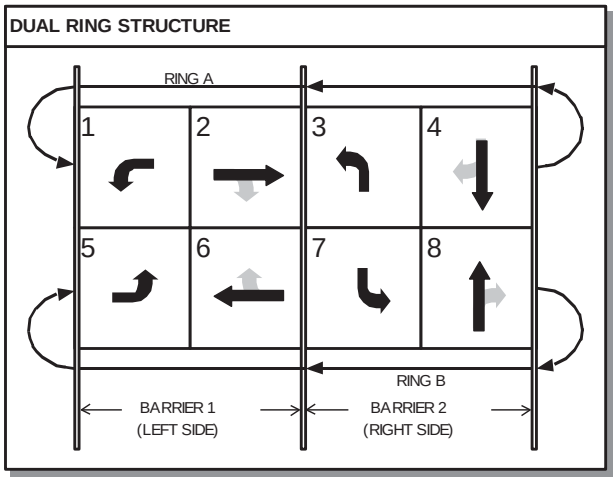
Exhibit 3-3 Common Phase Numbering Scheme



Dual Ring Control

By contrast to the pre-timed controller unit, the traffic actuated controller usually employs a "dual ring concurrent" timing process. The NEMA concept is illustrated in **Exhibit 3-4**.

Exhibit 3-4 Dual Ring Control



The dual-ring controller uses a maximum of eight phase modules, each of which controls a single traffic signal face with red, yellow and green display. The eight phases are required to accommodate the eight movements (four through and four left turns) at the intersection. Phases 1 through 4 are included in ring 1, and phases 5 through 8 are included in ring 2. The two rings operate independently, except that their control must cross the "barrier" at the same time.

If the movements to be controlled by these eight phases are assigned properly, the controller will operate without giving the right-of-way simultaneously to conflicting movements. All of the movements from one street (usually the major street) must be assigned to the left side of the barrier. Similarly, all movements from the other street must be assigned to the right side.

On both sides of the barrier there are four movements (two through and two left). Each of the four may proceed without conflict with two of the other three. So if the left turn in any given direction is placed in ring 1 along with its opposing through movement, and the remaining two movements are placed in ring 2, it will be possible for either movement in ring 1 to be displayed simultaneously with either movement in ring 2 without conflict.

The dual-ring concurrent operation can be shown to maximize the operating efficiency at an intersection by eliminating the "slack" time on each cycle (i.e., control will follow one or the other of the two paths shown).

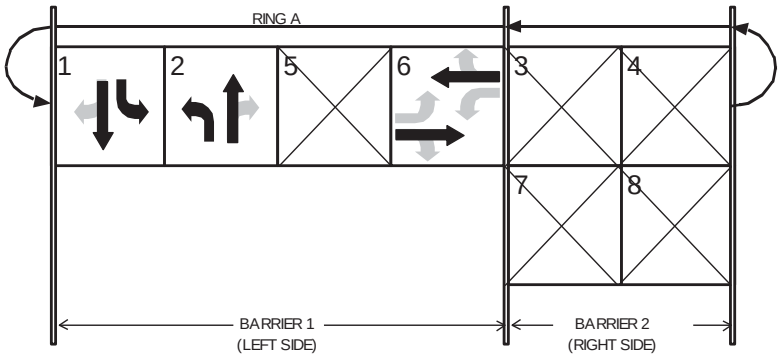
Modern controllers offer more flexibility in assigning traffic signal phases in order to control many complex or unique situations. TS2 controllers include four timing rings and up to sixteen vehicle phases and sixteen pedestrian phases. Each phase can be assigned to any ring. In addition, there are up to sixteen overlap assignments.

Single Ring (Sequential Phases)

Sometimes it is desirable to use a single ring and have the phases operate one at a time sequentially. Each phase is individually timed and can be skipped if there is no demand for it. This is called sequential or exclusive phasing. When using sequential phases on the left side of the barrier, phases 1-2-5-6 show in order. When using sequential phases on the right side of the barrier, phases 3-4-7-8 show in order.

Exhibit 3-5 is an example of a controller using Sequential phases. North and South traffic use split phasing, East and West share a phase.

Exhibit 3-5 Sequential Phasing



Multi-Rings and Barriers

A controller supporting more than eight phases and two rings would be a multi-ring controller. Any number of phases, up to the maximum supported by the controller, can be arranged in any number of rings. Conflicts between phases in different rings are specified using either barriers inserted between groups of phases, or phase concurrency lists. Exhibit 3-6 illustrates 16 phases in a quad-ring / quad-barrier structure.

Exhibit 3-6 Multi-Ring Phasing

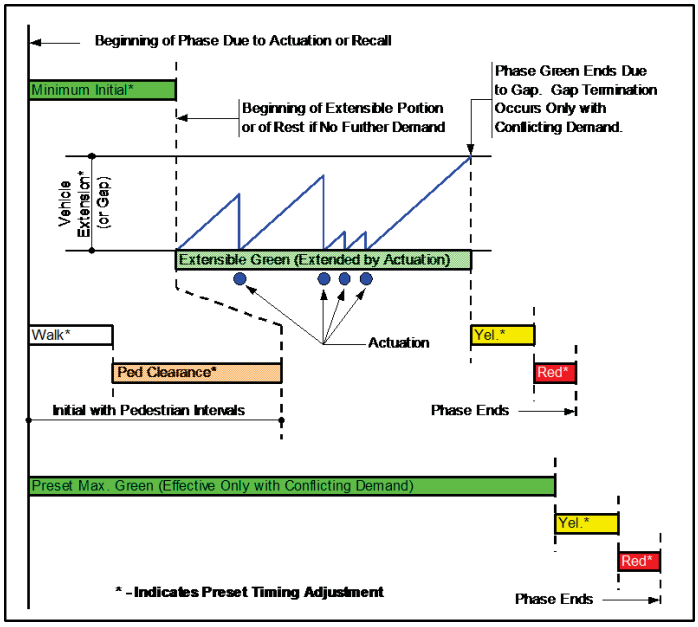
	Barrier 1				Barrier 2				Barrier 3				Barrier 4			
Ring 1	Phase 1	Phase 2			Phase 3	Phase 4			Phase 9	Phase 10			Phase 11	Phase 12		
Ring 2	Phase 5	Phase 6			Phase 7	Phase 8			Phase 13	Phase 14			Phase 15	Phase 16		
Ring 3																
Ring 4																

Phasing Parameters

Some of the basic principles of timing the green interval in a traffic actuated controller unit are as follows:

- ✓ There must be a **minimum green** time so that a stopped vehicle that receives a green signal has enough time to get started and partially across the intersection before the yellow signal appears. This time is termed the **initial portion** of the green interval.
- ✓ Each following vehicle requires green time. This is called **passage time**, **vehicle extension,** or **gap**. Gap refers to the distance between vehicles as well as the time between vehicles.
- ✓ There must be a **maximum time** that the green interval can be extended if opposing cars are waiting - this is called **extension limit** or **maximum**.
- ✓ A timing diagram for one traffic actuated phase is shown in the figure that follows. The other phase or phases operate in the same manner.
- ✓ The number of "presets" is the number of timing adjustments in the **extensible portion**. Each detector actuation starts the unit extension timing again. With no opposing calls the controller rests. Unit extensions continue being timed, but with no effect on the green interval.
- ✓ However, once an **actuation** is received from an opposing phase, unit extension is used to expedite servicing that phase as follows: if the time between actuations is greater than the preset unit extension or gap the extensible portion will be ended, the yellow change interval will appear and the next phase in sequence with demand will receive the right-of-way. This is called termination by gap or **gap-out**.
- ✓ An actuation from another phase received in any portion of the green interval also starts another timing circuit. This is called the extension limit or maximum green. Even if actuations are close enough in time to prevent gap termination, the maximum limit will terminate the green interval when the preset maximum expires. This is called termination by maximum green or **max-out**.

Exhibit 3-7 Traffic Actuated Phase Timing Diagram



Minimum Green

The Minimum Green Interval is the shortest green time of a phase. If a time setting control is designated as "minimum green," the green time shall be not less than that setting. For MnDOT practice on minimum green (minimum initial) times, refer to page 4-7.

Initial Intervals

There are three types of initial intervals as follows:

- ✓ Extensible initial
- ✓ Added initial
- ✓ Computed initial

Extensible initial is the method of calculating the variable initial period commonly used in field practice. This method adds the time specified as "seconds per actuation" to the minimum initial (green) for each vehicle actuation received by a phase during the yellow and/or red signal (depending on red and yellow lock) up to a maximum initial time. This method is common in both 170 and NEMA controllers.

Added initial is similar to extensible initial with the exception that the "seconds per actuation" calculation does not begin until a user specified number of vehicles actuations have occurred. The added initial option is generally used when long minimum green times are specified.

Computed initial calculates the amount of time given to each vehicle actuation (computed seconds per actuation) during the red signal display of the phase based on the following formula:

(Maximum initial interval time) ÷ (number of actuations that can be serviced during the minimum initial interval) x (number or recorded actuations). The total time allowed for the computed initial interval is limited by both the minimum green and maximum initial interval.

Passage Time

Passage Time (also referred to as vehicle extension or gap time) is the time that the phase will be extended for each actuation. Passage time is typically set as the time it takes to travel from the vehicle detector to the stop line at the travel speed of the roadway for pulse loops or the average acceptable headway between vehicles for presence loops located close to the stop line. Therefore, the vehicle extension is related to the minimum and maximum gap. For MnDOT practice on passage time refer to page 4-18.

Maximum Green

Depending on the type and manufacturer of the controller being simulated, there can be two methods for calculating the maximum amount of green time allowed per phase. Method 1 or maximum green, allows the user to input the maximum amount of green time a phase will be allowed to be active, (i.e. display green.) The max. timer in the controller begins its countdown at the receipt of a conflicting vehicle or pedestrian call, generally the beginning of phase green and includes any minimum green or variable initial period.

Method 2, maximum green extension, is the amount of time a phase will be allowed service after the minimum green and variable initial have timed out. While some controller manufacturers still allow maximum green extension, it is more commonly found in older isolated NEMA and Type 170 controllers. Assuming that vehicle headways remain less than the vehicle extension time during the green signal display of the phase, Method 1 will always produce the same timing value. However, in Method 2 the total green time is not only dependent on vehicle headways during the phase green but also on the number of vehicles that arrive during the red display for the calculation of variable initial. Therefore, total green time for Method 2 can vary from cycle to cycle irrelevant of vehicle headways.

If the controller is operating within a coordinated system the maximum green time specified in the controller may not be appropriate for the cycle/split combination selected by the master controller. In this case the phase can max-out early without ever reaching the force-off point (the end of the assigned phase split) for the phase.

Note: In certain manufacturers' controllers, there will be a timing function called "MAX EXT." This is not the same as maximum extension green but the number of seconds used to extend the maximum green value when "MAX 3" is active.

For MnDOT practice on maximum green times, refer to page **4-20**.

Pedestrian Phasing

Because pedestrians move at a slower speed than vehicles, they require different treatment of the green interval. A pedestrian actuation, therefore, results in more green time than would be allowed for a vehicle: a "Walk" interval followed by a flashing "Don't Walk" pedestrian clearance. In the absences of opposing calls, succeeding pedestrian actuations will recycle the pedestrian indications.

- ✓ Pedestrian intervals result in a green interval for the parallel vehicle phase or phases. **Exhibit 3-7** on the page **3-11** shows the timing diagram for pedestrian operation.
- ✓ It is also possible to have an exclusive pedestrian phase. That is, no vehicle green intervals will occur. All pedestrian signals at an intersection could be controlled by this phase.

Red Vehicle Clearance

Red clearances (ALL RED) is the safety clearance interval at the end of a phase that displays red for all traffic movements. For MnDOT practice on red clearance intervals see page **4-23**.

Recall

Normally a controller unit will, in the absence of actuation, rest on the last phase serviced. By means of a recall switch the controller unit can be forced to return to a particular phase's green interval, even with no demand.

Every phase has the capability of operation with the following types of recall:

- ✓ *Minimum Recall*. When active and in the absence of a vehicle call on the phase, a temporary call to service the minimum initial time will be placed on the phase. If a vehicle call is received prior to the phase being serviced the temporary call will be removed. Once the phase is serviced it can be extended based on normal vehicle demand.
- ✓ *Maximum Recall.* With the maximum vehicle recall active a constant vehicle call will be placed on the phase. This constant call will force the controller to time the maximum green. Maximum recall is generally used to call a phase when local detection is not present or inoperative.
- ✓ *Pedestrian Recall.* This feature provides vehicle green and pedestrian walk and clearance intervals. After that, normal green timing is in effect except that pedestrian calls will not recycle pedestrian intervals until opposing phases are serviced.
- ✓ In addition, a phase has a vehicle call placed on it if it is terminated with some passage time remaining. This can happen with termination by maximum.
- ✓ If all of the active phases of a controller unit are placed on recall the controller unit will operate in a pre-timed mode. It should be added that unless the detectors are disconnected from a phase, that phase's green interval could be extended beyond the preset minimum if the recall is to minimum.

Care must be taken when considering the operation of EVP with permissive left turns (see page 3-20 for a discussion on permissive left turns) to prevent left turn trapping (see page 3-31). Using EVP with a flashing yellow arrow will prevent the trap problem as discussed on page 3-33.

Transit Signal Priority

Bus priority or transit signal priority (TSP) is a name for various techniques to improve service and reduce delay for mass transit vehicles at intersections (or junctions) controlled by traffic signals. TSP techniques are most commonly associated with buses, but can also be used along streetcar, tram, or light rail lines that mix or conflict with general vehicular traffic.

Transit signal priority techniques can generally be classified as active or passive. Passive TSP techniques typically involve optimizing signal timing or coordinating successive signals to create a "green wave" for traffic along the transit line's route. Passive techniques require no specialized hardware (such as bus detectors and specialized traffic signal controllers) and rely on simply improving traffic for all vehicles along the transit vehicle's route.

Active TSP techniques rely on detecting transit vehicles as they approach an intersection and adjusting the signal timing dynamically to improve service for the transit vehicle. Unlike passive techniques, active TSP requires specialized hardware: the detection system typically involves a transmitter on the transit vehicle and one or more receivers (detectors), and the signal controller must be "TSP capable", i.e. sophisticated enough to perform the required timing adjustments. This operation requires special coordination programming of the controller that is separate from EVP and regular coordination programming.

Active strategies include:

- ✓ **Green Extension**: This strategy is used to extend the green interval by up to a preset maximum value if a transit vehicle is approaching. Detectors are located so that any transit vehicle that would just miss the green light ("just" meaning by no more than the specified maximum green extension time) extends the green and is able to clear the intersection rather than waiting through an entire red interval.
- ✓ **Early Green (aka red truncation)**: This strategy is used to shorten the conflicting phases whenever a bus arrives at a red light in order to return to the bus' phase sooner. The conflicting phases are not ended immediately like they are for emergency vehicle preemption systems but are shortened by a predetermined amount.
- ✓ **Early Red**: If a transit vehicle is approaching during a green interval, but is far enough away that the light would change to red by the time it arrives, the green interval is ended early and the conflicting phases are served. The signal can then return to the transit vehicle's phase sooner than it otherwise would. Early red is largely theoretical and is not commonly used in practice.
- ✓ **Phase Rotation**: The order of phases at the intersection can be shuffled so that transit vehicles arrive during the phase they need.
- ✓ **Actuated Transit Phase(s)**: These are phases that are only called if a transit vehicle is present. These might be seen along streetcar lines or on dedicated bus lanes.
- ✓ **Phase Insertion**: This strategy allows a signal controller to return to a critical phase more than once in the same cycle if transit vehicles that use that phase are detected.

3.5 Left Turn Phasing

There are five options for the left-turn phasing at an intersection: permissive only, protected only, protected-permissive, split phasing, and prohibited. Phasing can have a significant impact on signal system effectiveness for a number of reasons, including:

- ✓ Permissive only left turn operation may reduce delay for the intersection, but may adversely affect intersection safely, because it requires motorists to choose acceptable gaps.
- ✓ Protected only left-turn phases may reduce delay for turning vehicles but are likely to increase overall intersection delay.
- ✓ Protected-permissive left turn phases can offer a good compromise between safety and efficiency but could limit available options to maximize signal progression during coordination unless innovative displays are used.
- ✓ Split phasing may be applicable with shared lanes, but could increase coordinated cycle length if both split phases are provided a concurrent pedestrian phase.
- ✓ Prohibited left turns may be used selectively to reduce conflicts at the intersection.

Protected and Permissive Left Turn Phasing

If a protected left turn phase is to be used (left turn made without conflicts with opposing traffic) left turns may or may not also be permitted on a circular green or Flashing Yellow Arrow (see page 3-24) indication with opposing traffic.

In general, it is desirable to allow this permissive left turn movement unless there are overriding safety concerns which make such phasing particularly hazardous.

- ✓ Use of a permissive left turn can significantly reduce overall intersection delay as well as delay to left turners.
- ✓ Use of permissive left turn phasing may reduce the required length of left turn storage on the approach and allow an approach with substandard left turn storage to operate more efficiently.

Certain situations exist where safety considerations generally precluded the use of permissive left turns. In these cases, left turns should be restricted to the exclusive left turn phases. Such situations include:

- ✓ Intersection approaches where crash experience or traffic conflicts criteria are used as the basis for installing separate left turn phasing.
- ✓ Blind intersections where the horizontal or vertical alignment of the road does not allow the left turning driver adequate sight distance to judge whether or not a gap in on-coming traffic is long enough to safely complete his turn.
- ✓ High-speed and/or multilane approaches may make it difficult for left turning drivers to judge gaps in oncoming traffic. Such locations should be evaluated on an individual basis.
- ✓ Unusual geometric or traffic conditions may complicate the driver's task and necessitate the prohibition of permissive left turns. An example of such conditions is an approach where dual left turns are provided.
- ✓ When normal lead-lag phasing is used (due to left turn trapping).

Some of the issues noted above that preclude the use permissive left turns may only be applicable during certain times of the day. Traditionally, this would require protected only operation for the entire day. The use of the FYA display (see page 3-24) would allow the indication to operate as protected only during some times of the day and permissive or protected/permissive during others. The use of the FYA display can also eliminate the left turn trapping problem that is discussed in the next section.

Left Turn Phasing Sequence

A critical element to the operation of a traffic signal is the determination of the appropriate phasing sequence. At signalized intersections where traffic volumes are heavy or speeds are high, vehicles attempting to turn left across opposing traffic may constitute significant safety and capacity problems. Based on this, there are additional considerations for determining the left turn phasing alternative. These include:

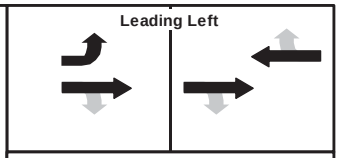
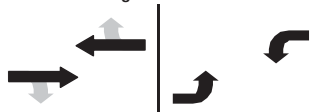
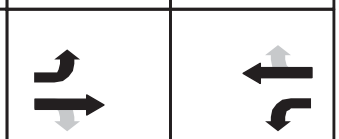
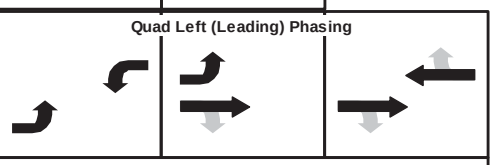
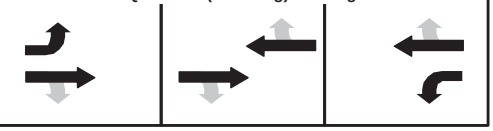
- ✓ *Heaviest Left Turn Protected* - This is a leading left phase scheme in which the left-turning vehicles from only one approach are protected and move on an arrow indication proceeding the opposing through movement; or a lagging left when the protected left turn follows the through movement phase.
- ✓ *Both Left Turns Protected (Without Overlap)* - When the opposing left turns move simultaneously followed by the through movements, it is called a "lead dual left". If the left turns follow the through movement, it is called a "lag dual left".
- ✓ *Both Left Turns Protected (With Overlap)* - In this operation, opposing left turns start simultaneously. When one terminates, the through movement in the same direction as the extending left movement is started. When the extended left is terminated, the remaining through movement is started. When this type of phasing is used on both streets, it is termed "quad left phasing".
- ✓ *Lead Lag* - This phasing is combined with a leading protected left in one direction, followed by the through movements, followed by a lag left in the opposing direction. It is sometimes used in systems to provide a wider two-way through band.
- ✓ *Directional Separation (Split)* - First, one approach moves with all opposing traffic stopped, then the other approach moves with the first approach stopped.

Exhibit 3-11 shows the above basic left turn phasing schemes.

Whether or not separate left turn phasing should be provided is a decision that must be based on engineering analysis. This analysis may involve serious trade-offs between safety, capacity, and delay considerations.

- ✓ Separation of left turns and opposing traffic may reduce crashes that result from conflicts between these movements, and may increase left turn capacity. However, through traffic capacity may be reduced.
- ✓ Left turn phasing may reduce peak period delay for left turners, but may increase overall intersection delay. Off-peak left turn delay may also increase.

Exhibit 3-11 Left Turn Phasing

Heaviest Left Turn Protected This is a leading left phase scheme in which the left-turning vehicles from only one approach are protected and move on an arrow indication proceeding the opposing through movement; or a lagging left when the protected left turn follows the through movement phase.	Leading Left  - OR - Lagging Left 
Both Left Turns Protected (Without Overlap) When the opposing left turns move simultaneously followed by the through movements, it is called a "lead dual left". If the left turns follow the through movement, it is called a "lag dual left".	Lead Dual Lefts  - OR - Lag Dual Lefts 
Directional Seperation (Split) First, one approach moves with all opposing traffic stopped, then the other approach moves with the first approach stopped.	
Both Turns Protected (with Overlap) In this operation, opposing left turns start simultaneously. When one terminates, the through movement in the same direction as the extending left movement is started. When the extended left is terminated, the remaining through movement is started. When this type of phasing is used on both streets, it is termed "quad left phasing". ***Lead Lag*** phasing is combined with a leading protected left in one direction, followed by the through movements, followed by a lag left in the opposing direction. It is sometimes used in systems to provide a wider two-way through band. .	Quad Left (Leading) Phasing  - OR - Quad Left (Lead Lag) Phasing 

3.6 Flashing Yellow Arrow Display

The Flashing Yellow Arrow (FYA) head is a signal that uses a flashing yellow arrow indication for permissive left turns instead of using a green ball. A 7-year national study determined that the 4-section FYA signal head with a red arrow on top, followed by a steady yellow arrow, a flashing yellow arrow, and then a green arrow on the bottom was the best and safest type of left-turn signal head based on driver confirmation and field implementation studies.

The FYA head is now the recommended left turn head in the Federal 2009 Manual of Uniform Traffic Control Devices (MUTCD). This version of the MUTCD includes language on the use of the flashing yellow arrow for permitted left turns that states:

> "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 within 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."

MnDOT does encourage the use of FYA whenever appropriate. Additional details on the FYA can be found by visiting:

http://www.dot.state.mn.us/trafficeng/signals/flashingyellowarrow.html

http://mutcd.fhwa.dot.gov/resources/interim_approval/ia_10_flashyellarrow.htm

http://www.fhwa.dot.gov/publications/research/safety/09036/index.cfm

Refer to Page **3-28** for a handout technical memo on the use of the FYA in Minnesota.

3.7 Minnesota Flashing Yellow Arrow

The section on "**Flashing Yellow Arrow Display**" in the previous section discusses the FYA from a national and Federal MUTCD perspective. The following sections discuss the use of the FYA within Minnesota.

The discussions in this section "Minnesota Flashing Yellow Arrow" are current at the time of printing this publication. However, the items mentioned are anticipated to be continually changing. Please be sure to constently check the MnDOT website for updates (See www.dot.state.mn.us/trafficeng/).

Variable vs. Fixed Phasing Operation Signal Heads

Traditionally, the operation of the left turn signal was considered fixed. That is, if a protected left turn head was installed, then this signal would operate in protected operation for the entire day. It may be that a protected left is desirable for a specific time of day (i.e., heavy opposing flow is the reason for the protected operation), but this may "penalize" the other twenty-three hours of the day that do not require protected-only operation. One advantage to

the FYA signal indication is that it can change the mode of operation on a time of day (TOD) basis. In summary:

- ✓ The FYA head is a "variable phasing operation" head that can operate with either protected, protected/permissive, or permissive phasing operation by time-of-day settings.
- ✓ Standard 3-section protected and 3-section permissive heads are "fixed phasing operation" heads that can only operate in one phasing operation 24 hours a day.
- ✓ Given that the FYA head can operate protected 24 hours a day, if desired, the standard 3-section protected head will soon become obsolete as there is no reason to install a 3-section protected head and not have the ability to change the phasing operation in the future.
- ✓ Standard 5-section heads are "flexible phasing operation" heads, but only with either protected/permissive or permissive operation by time-of-day settings.

TEM Information on Flashing Yellow Arrows

The information on the following page is a handout from the Traffic Engineering Manual (TEM) regarding the use of the FYA.

3.8 Left Turn Trapping

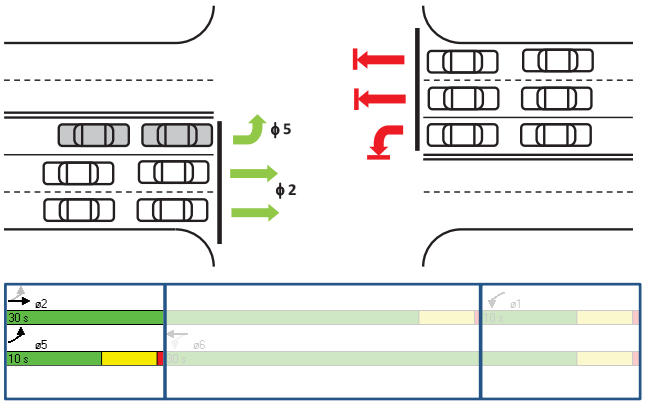
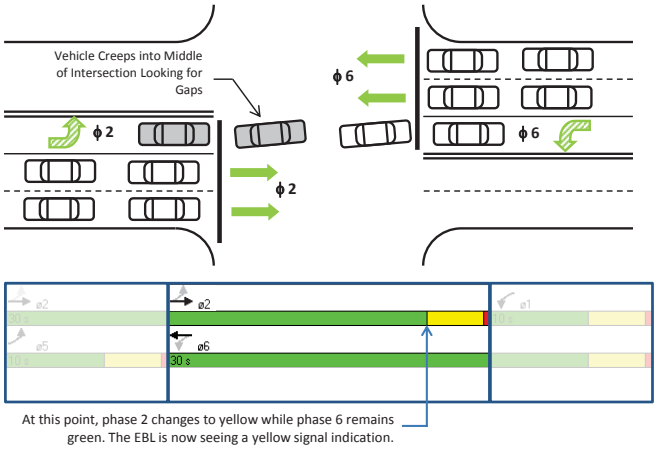
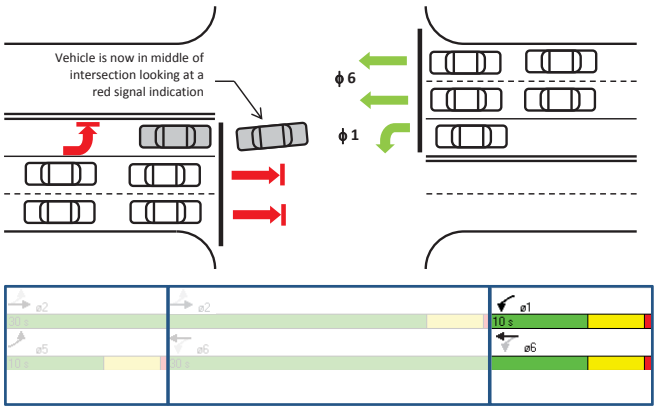
As noted earlier, the combination of a permitted left turns with lead-lag creates a situation commonly called the "left-turn trap" (when no FYA is used).

Consider **Exhibit 3-12** for an eastbound leading left scenario. There is no real problem with the westbound situation here; these left turners are presented in stage 2 with a green ball after a period of obvious opposing flow. It is clear they must yield to the eastbound through traffic. In stage 3 this movement is protected and, again three is no problem. The transition is given by green ball direct to green arrow, but even if a yellow ball was displayed at the end of stage 2, there is no problem.

The problem is with the eastbound left turns. If this scenario is allowed, any left turner who had not been able to find a gap during the stage 2 green would be presented with a yellow indication at its end. Since these drivers see a yellow indication on all facing displays (through and left), they may incorrectly presume that the westbound through is likewise receiving a yellow indication and is about to stop. When the signal turns red (eastbound) the turner will: 1) at best be stuck (now illegally), in the middle of the intersection with nowhere to go, or 2) at worst commit the left turn thinking the opposition is stopping creating a serious safety issue.

Refer to page **3-33** for information on how the flashing yellow arrow can eliminate the left turn trap condition.

Exhibit 3-12 Lead/Lag Left Turn Trap

	**Stage 1**: Phase 5 eastbound (EBL) shows a protected left turn arrow while phase 2 eastbound shows a green ball. The opposing WB movements are stopped. No issues during this stage; the left turn vehicles have a protected movement.
	**Stage 2**: The EBL and WBL now operate as permitted lefts (sees a green ball indication). During this stage, the EBL may creep into the middle of the intersection looking for gaps in the opposing traffic. Note that the EBL is actually operating as Phase 2 permitted. At the end of this stage is when the problem occurs. Phase 2 indications will change to yellow. The EBL vehicle now has to consider how to clear the intersection and may falsely assume the opposing through is seeing a yellow indication and is about to stop. In fact, the WBT remains green since phase 1 WBL is up next.
	**Stage 3**: Now, phase 1 WBL shows a green arrow (protected) operation while phase 6 WBT remains green. The EBL may have assumed the WBT was stopping and attempts to sneak through the intersections creating a crash situation.

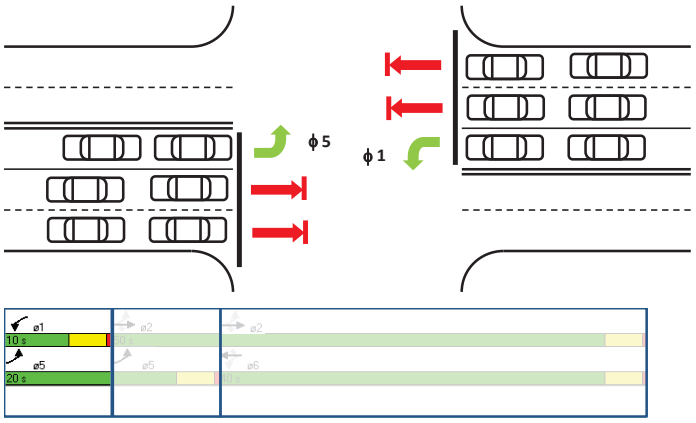
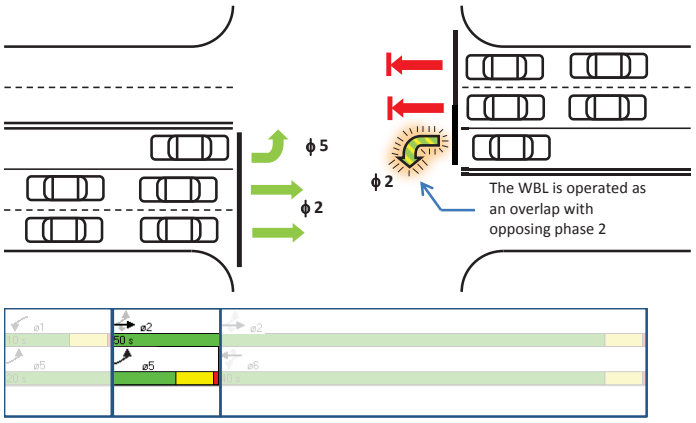
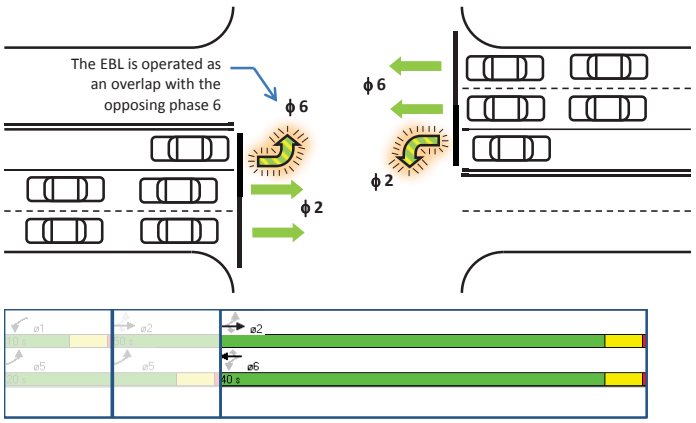
Flashing Yellow Arrow and the Left Turn Trap

Exhibit 3-12 illustrates a left turn trap with traditional lead/lag phasing (i.e., a green ball indication is used for the permitted left turns). Using a FYA indication can eliminate the trap condition illustrated in this exhibit.

Once again, consider the EBL vehicle. During stage 1, the EBL receives a green arrow and proceeds under the protected movement. During stage 2, the EBL shows the flashing yellow arrow indication and the movement operates as a permissive movement. In stage 3, the EBL remains a flashing yellow arrow indication instead of turning red. The EBL FYA actually operates as an overlap to phase 6. Therefore, the EBL and opposing WBT terminate at the same time as expected by the driver.

Exhibit 3-13 illustrates the signal operation of the FYA even under the "soft-trap" condition and how this can be eliminated.

Exhibit 3-13 FYA to Eliminate Left Turn Trap

	**Stage 1**: During this stage, normal leading protected and opposing left turn phases operate. This is the typical operation even with a traditional 5-section signal indication. At the end of this stage, phase 1 clears the intersection with a solid yellow arrow.
	**Stage 2**: During this stage phase 2 begins green as phase 5 continues green in normal operation. The opposing left turn is operated as a FYA. In a traditional 5-section operation, the opposing left turn would be red.
	**Stage 3**: In this stage, phase 2 and 6 throughs receive a green ball indication. The opposing lefts are operated as an FYA overlap with the opposing through. This will ensure that the left turn clears (turns yellow) and then red with the opposing through, thus eliminating the left turn trap.

4.5 Pedestrian Timing Requirements

This section will cover the WALK and PEDESTRIAN CLEARANCE (*flashing* DON'T WALK) parameters.

The MN MUTCD requires that pedestrians should be assured of sufficient time to cross the roadway at a signalized intersection. This must be shown with the vehicle and/or pedestrian indications. In the absence of pedestrian indications, the minimum green + yellow + all red time must be equal to pedestrian timing (walk + pedestrian clearance).

The MN MUTCD meaning of pedestrian signal indications are summarized as follows:

- ✓ WALK indication, means that pedestrians may begin to cross the roadway in the direction of the indication.
- ✓ *flashing* DON'T WALK indication, means that a pedestrian shall not start to cross the roadway in the direction of the indication, but that any pedestrian who has partly completed their crossing shall continue to a sidewalk, or to a safety island.
- ✓ steady DON'T WALK indication, means that a pedestrian shall not enter the roadway in the direction of the indication.

Signal controllers used by MnDOT do not time the yellow vehicle indication concurrent with the flashing DON'T WALK. Because of this, a portion of the yellow interval may be included in the pedestrian clearance time (i.e., the pedestrian clearance time is equal to flashing DON'T WALK interval plus the yellow interval)

Walk

The MN MUTCD states, "Under normal conditions, the WALK interval should be at least 4 to 7 seconds in length so that pedestrians will have adequate opportunity to leave the curb before the clearance interval is shown." Research indicates that queues (more than 24 people) requiring more than 7 seconds to discharge occur very rarely and will usually be found only in certain sections of large metropolitan areas. The minimum WALK interval under low volume (less than 10 pedestrians per cycle) conditions could possibly be lowered to 4 - 5 seconds but the importance of the inattentiveness factor should be also weighted in this decision.

Flashing Don't Walk

The duration of the pedestrian clearance time should be sufficient to allow a pedestrian crossing in the crosswalk who left the curb or shoulder 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.

The *flashing* DON'T WALK interval is determined by the following formula:

flashing DON'T WALK = D/R

D = Distance from the near curb or shoulder to at least the far side of the traveled way or to a median of greater than 6 feet.

R = Walking rate of 3.5 feet per second assumed walking rate unless special conditions (school kids, elderly or handicapped) require a slower walking rate.

When determining the distance, consideration should be given to the pedestrian's normal walking path. Pedestrian timing should consider the pedestrian walking to the nearest pedestrian and/or vehicle indication following a marked or unmarked crosswalk.

On median divided roadways, consideration should be given to providing sufficient time to the pedestrians to cross both roadways. A pedestrian's goal is to cross the total roadway and does not expect to stop at the

dividing median and wait till the next cycle. If the median is less than 6 feet wide the pedestrian should be provided sufficient time to cross both roadways as a median less than 6 feet wide is not considered a safe refuge island.

Normal walking speed is assumed to be 3.5 feet per second. This is as cited in the 2009 Federal MUTCD and will be the walking speed used in the pending update to the MN MUTCD. In selecting a walking rate, consideration must be given to the type of pedestrians, volume of pedestrians, intersection location and geometrics and overall signal operation.

Signal controllers used by MnDOT do not time the yellow vehicle indication concurrent with the flashing DON'T WALK. This is assuming minimum vehicle green time. The steady DON'T WALK is displayed at the onset of yellow to encourage any pedestrians still in the street to complete the crossing without delay. Because of this and a MN MUTCD Ruling No. IV-35, Pedestrian Clearance Interval Calculation, the yellow interval may be included in the pedestrian clearance time (i.e., the pedestrian clearance time is equal to flashing DON'T WALK interval plus the yellow interval). The *flashing* DON'T WALK interval could then be determined by the following formula:

flashing DON'T WALK = (D/R) - Yellow

However, the ruling also states, "Discretion should be used in utilizing the latitude afforded by Section 4E". Therefore, as a general practice, this should not be followed unless it is necessary to minimize the pedestrian timing. By subtracting the yellow interval, pedestrians may receive the steady DON'T WALK before they reach the far side of the farthest traveled lane. Engineering studies and judgment should be exercised in determining walking rates, distances and utilizing the yellow interval as part of the pedestrian clearance interval.

Pedestrian Timing Recommended Practice

Pertinent sections of the Federal MUTCD can be found on page 4-7.

For single roadways, and divided roadway with median island less than 6 feet wide and pedestrian indications on each side, the pedestrian will be provided time to cross from the near side curb or shoulder to the far side of the traveled way.

WALK = 7 seconds

(this may be reduced to 4 seconds if it is necessary to minimize pedestrian timing considering the other factors)

flashing DON'T WALK = (D/R)

(time should not be less than WALK time and the time may be reduced by the yellow interval if it is necessary to minimize pedestrian timing considering other factors)

D = Distance from the near curb or shoulder to at least the far side of the traveled way.

R = Walking rate of 3.5 feet per second is the assumed walking rate unless special conditions (school kids, elderly or handicapped) require a slower walking rate.

Divided Roadways

A divided road is one with a median island over 6 feet wide **and includes a pedestrian pushbutton in the median**. If a pushbutton is not in the median, the recommended practice above must be used (i.e., the pedestrian clearance interval must cross them completely from near side curb to far side curb).

Option 1 - Cross to Median Only

(Pedestrian indications present)

The WALK and *flashing* DON'T WALK should be determined as above. The crossing distance should be determined by using the longest distance from the curb or shoulder to the median. The pedestrian will be provided time to cross to the median on one cycle and time to cross the other side on the next cycle when the pedestrian push button is activated.

Option 2 - Cross Completely

In order for the pedestrian to cross the total roadway, the WALK indication must take the pedestrian past the median island before the flashing DON'T WALK is displayed. If the flashing DON'T WALK is displayed before the pedestrian reaches the median island, the pedestrian should stop at the median island and wait till the next WALK indication. The following special timing should allow the pedestrian to cross both roadways.

This timing also provides for a pedestrian that may start to cross the first roadway at the end of WALK. This pedestrian is provided enough flashing DON'T WALK to reach the median island and finish the crossing on the next WALK indication.

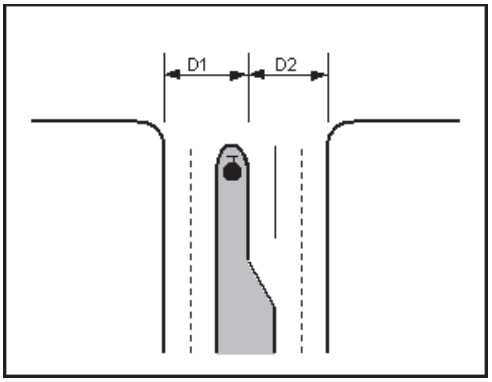
WALK = D1/R

flashing DON'T WALK = (D2/R)

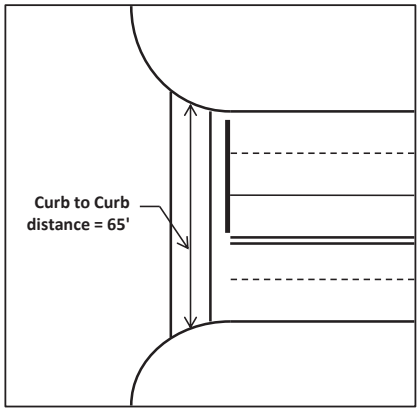
(this time may be less than the WALK time and the time may be reduced by the yellow time if it is necessary to minimize the pedestrian timing considering other factors)

Refer to **Exhibit 4-2** for D1 and D2 determination.

Exhibit 4-2 Pedestrian Crossing Distances



Example: Consider the intersection shown below.



Assume a walking speed of 3.5 feet per second with no special pedestrian requirements.

The pedestrian clearance would then be, FDW = 65 feet / 3.5 feet per second = **19 seconds**

Accessible Pedestrian Signals (APS)

Refer to Section **4.11** on page **4-33** for information on APS.

Pedestrian Timing (MN MUTCD)

The following information is from the MN MUTCD. The latest information can be found by visiting the OTST website, www.dot.state.mn.us/trafficeng/publ/mutcd/index.html.

Exhibit 4-4 Yellow Timing Values

Posted Speed	Percent Grade							MnDOT
	+3	+2	+1	Level	-1	-2	-3	
25	2.7	2.7	2.8	2.8	2.9	3.0	3.0	**3.0**
30	3.0	3.1	3.1	3.2	3.3	3.4	3.4	**3.5**
35	3.3	3.4	3.5	3.6	3.7	3.7	3.8	**4.0**
40	3.7	3.8	3.8	3.9	4.0	4.1	4.3	**4.0**
45	4.0	4.1	4.2	4.3	4.4	4.5	4.7	**4.5**
50	4.4	4.5	4.6	4.7	4.8	4.9	5.1	**5.0**
55	4.7	4.8	4.8	5.0	5.2	5.3	5.5	**5.5**
60	5.0	5.1	5.1	5.4	5.6	5.7	5.9	**6.0**
65	5.4	5.5	5.5	5.8	5.9	6.1	6.3	**6.0**

Yellow Interval for Left Turns

MnDOT will often use 25 mph (or a value of 3.0 seconds) for left turns. If timing a single point urban interchange (SPUI) or an intersection with a wide, sweeping radius, assume a speed of 35 mph. For information on the yellow interval for a FYA, refer to page 4-26.

All Red

The following formulas may be used to determine the red time. This is based on the Institute of Transportation Engineers (ITE) equation for red clearance interval.

$$R = \frac{w + L}{1.467v}$$

English

R = All red clearance interval in seconds

w = width of intersection, stop line to ~~center~~ the end of the farthest conflicting lane

l = length of vehicle, assumed to be 20 feet

v = posted speed in mile per hour

Exhibit 4-5 All Red Times

Posted Speed	Width of Intersection								
	30	40	50	60	70	80	90	100	110
25	1.4	1.6	1.9	2.2	2.5	2.7	3.0	3.3	3.5
30	1.1	1.4	1.6	1.8	2.0	2.3	2.5	2.7	3.0
35	1.0	1.2	1.4	1.6	1.8	1.9	2.1	2.3	2.5
40	0.9	1.0	1.2	1.4	1.5	1.7	1.9	2.0	2.2
45	0.8	0.9	1.1	1.2	1.4	1.5	1.7	1.8	2.0
50	0.7	0.8	1.0	1.1	1.2	1.4	1.5	1.6	1.8
55	0.6	0.7	0.9	1.0	1.1	1.2	1.4	1.5	1.6
60	0.6	0.7	0.8	0.9	1.0	1.1	1.3	1.4	1.5

These formulas are general and should only be used as a guide. Other factors at an intersection (such as approach grades, visibility, truck traffic and local traffic characteristics) should be considered. It is important that approach grades and truck traffic are considered in determining the yellow and red intervals. The yellow interval must not be too short (causing quick stops and/or red violations) nor too long (causing regular "driving of the yellow").

The all-red should be in the range of 1 to 5 seconds.

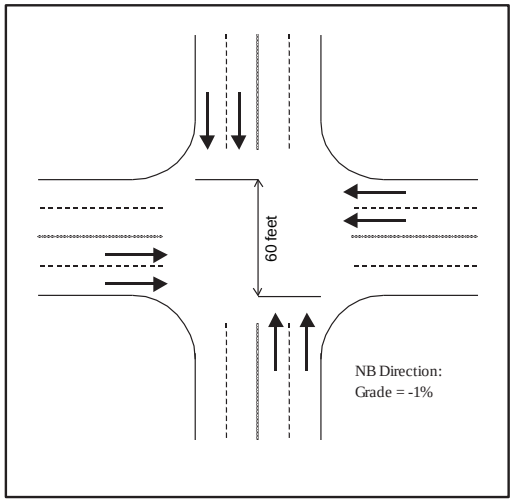
All Red for Left Turns

MnDOT will often use 25 mph for left turns. If timing a single point urban interchange (SPUI) or an intersection with a wide, sweeping radius, assume a speed of 35 mph.

The width of the intersection, w, for a left turn is commonly determined from a scaled intersection drawing. This distance (w) is measured along the path of the left turn vehicle from the stop to the end of the farthest conflicting lane.

For information on the all red interval for a FYA, refer to page **4-26**.

Example: Consider the intersection shown in the figure below.



Assume the following:

t = 1.0 seconds

v = 45 mph

a = 10 feet per second

l = 20 feet

g = -1 percent

$$Y + R = 1.0 + \frac{1.467\,(45)}{2\{10 + 32.2(-0.01)\}} + \frac{60 + 20}{1.467\,(45)}$$

Y + AR = 1.0 + 3.41 + 1.21 = 5.62 seconds

Use,

Yellow = 4.4 seconds and All Red = 1.2 seconds

5 COORDINATION CONCEPTS

5.1 Cycle Length

The cycle length is the total time to complete one sequence of signalization around an intersection. In an actuated controller unit, a complete cycle is dependent on the presence of calls on all phases. In a pre-timed controller unit (see page 3-5) it is a complete sequence of signal indications.

The equation presented on page 3-1 is for isolated pre-timed signal locations only. A detailed network analysis should be performed using a software package such as Synchro or TRANSYT for cycle length determination in a coordinated system. The use of computer models allows for multiple iterations of varying cycle combinations to determine the optimum signal timing parameters.

5.2 Signal Timing Intervals and Splits

The sum of the green, yellow, and all red intervals typically defines an individual phase **split**. A split is then the segment of the cycle length allocated to each phase that may occur (expressed in percent or seconds).

The primary considerations that must be given to vehicle split times are as follows:

- ✓ The phase duration must be no shorter than some absolute **minimum time**, such as five to seven seconds of green plus the required clearance interval. If pedestrians may be crossing with this phase, their crossing time must also be considered and included in the minimum phase length.
- ✓ A phase must be long enough to avoid over saturating any approach associated with it. Too short a time will cause frequent **cycle failures** where some traffic fails to clear during its phase.
- ✓ A phase length must not be so long that green time is wasted and vehicles on other approaches are delayed needlessly.
- ✓ Phase lengths should be properly designed to efficiently balance the cycle time available among the several phases, not just “equitably” between, say, north-south and east-west.

5.3 Offset

The **offset** is the time relationship, expressed in seconds or percent of cycle length, determined by the difference between a fixed point in the cycle length and a system reference point.

Proper determination and application of intersection offsets provide for the efficient movement of platoons through multiple intersections during the green indication. Properly timed offsets can significantly reduce delay and improve driver satisfaction with the system timing.

5.4 Progression Measures

All of the coordinated system analysis models have some MOEs associated with the green bands in the Time-Space Diagram (TSD). In fact some of the models utilize progression MOEs as a component of the optimization objective function. The more common of these MOEs are introduced below.

Bandwidth Efficiency

PASSER II uses this measure as its objective function. This is simply the proportion of the cycle that is included in through green bands, extending the entire length of the system. A simple TSD showing perfect time-space progression illustrates the concept. Mathematically, efficiency is calculated as:

Comparisons between "before" and "after" data should be performed for:

- ✓ System-wide measures-of-effectiveness output from the simulation models, and
- ✓ Field-collected measures such as travel time.

Also, refer to Chapter 4 for MnDOT's procedure to time a traffic control signal.

5.7 Traffic Signal Control Systems

System Concept

A system may be defined as an arrangement or combination of interacting or interdependent parts which form a unified whole serving a common purpose. The system concept as related to traffic signal control includes the methods, equipment, and techniques required to coordinate traffic flow along an arterial or throughout an area.

System Objective

The major objective of a traffic control system is to permit continuous movement and/or minimize delay along an arterial or throughout a network of major streets. This involves the selection, implementation, and monitoring of the most appropriate operational plan. Basically, a traffic signal system provides the appropriate and necessary timing plans for each intersection in terms of individual needs as well as the combined needs of a series of intersections.

Relationship of Timing Plans to Traffic Control

In the system concept a timing plan is defined by a combination of control parameters for one or more intersections based upon an analysis of demand. Timing plans can be provided as a function of equipment at the local intersection, the central control point, or both. Timing plans consist of:

1. *A system Cycle*. A specific cycle length is imposed throughout the system covered by the timing plan.
2. *Split*. All intersections in the system have defined splits which are the apportionment of the cycle to the various phases present at that intersection.
3. *Offset*. Each intersection has a unique offset. The offset is the relationship of the beginning of the main street green at this intersection to a master system base time. Offsets are generally expressed in seconds. Properly established offsets along a street can potentially provide for smooth traffic flow without stopping.

Basis of Selecting Timing Plans

The selection parameters which define timing plans include:

1. *Historic Data* Time of Day information compiled from traffic counts to reflect traffic volumes for specified time of day (morning peak, midday, afternoon peak, etc.) and day of week.
2. *Current Data* Real time on-street volumes from traffic detection equipment.
3. *Special Data* Special events, emergency route assignment, special right-of-way preemption (fire equipment, ambulances, buses, etc.)

Types of Traffic Signal Control Systems

Many combinations of methods, equipment, and techniques can comprise a traffic signal control system. Generally, these systems fall into the following basic types.

Time Based Coordinated (TBC) System

This form of coordination utilizes non-interconnected controllers with auxiliary devices called time based coordinators. These devices use the power company supplied frequency to keep time very accurately. Various timing plans can be established with time of day and day of week plan changes. Since all intersections use the same power source, the time-based coordinators provide coordination without physical interconnection.

Global Positioning System (GPS) receivers have been used for several years to provide a clock sync to ensure TBC is maintained.

Interconnected Pre-timed System

This type of system was originally developed for electromechanical controllers, but can also be used with some of the newer controllers. Local intersections are physically interconnected (usually by a 7-wire cable) to ensure coordinated operation. The system provides automatic re-synchronization should a signal go "out of step". The number of timing plans is a function of the number of dials and the number of offsets and splits per dial; the most common system consists of a three-dial, three-offset, one-split combination. Timing plans are normally selected by a time clock or time dependent programming device. The local controller for one intersection may act as master controller for the system.

Traffic Responsive System

Basically, this is an interconnected system utilizing a master controller for pattern (Cycle/offset/splits) selection. Traffic detectors are used to sample directional volumes and detector occupancy. Volume and occupancy metrics determine which of the available patterns is selected (i.e., inbound, outbound, or average) based on predetermined thresholds. The master controller may be an analog or a digital computer.

Interconnected Actuated Systems

Generally a small system with a master-slave relationship (i.e., two or more fully-or semi-actuated local controllers with one acting as system master and controlling cycle length for the other controllers). Offset capability is limited. A variation of this system uses a system master, coordinating units, and local actuated controllers. The master may be traffic responsive or combination of time clocks.

Traffic Adaptive System

Traffic adaptive systems perform "real-time" adjustments to the cycle length, splits and offsets in response to traffic demand. Traffic adaptive systems require extensive detection inputs. Complete and accurate traffic flow data must be gathered, processed and communicated to the central computer.

Advanced Traffic Management Systems (ATMS)

ATMS are capable of monitoring and controlling thousands of intersection controllers using state of the art architecture like TCP/IP and NTCIP. ATMS offer complete traffic and data management including real time field reporting for multiple users over distributed local and wide area networks and remote access.

ATMS offer scalable software solutions that support a range of users including:

- ✓ School zone flashers
- ✓ Freeway management
- ✓ CMS, VMS, DMS
- ✓ CCTV surveillance
- ✓ HOV lane control
- ✓ Reversible lane control signals

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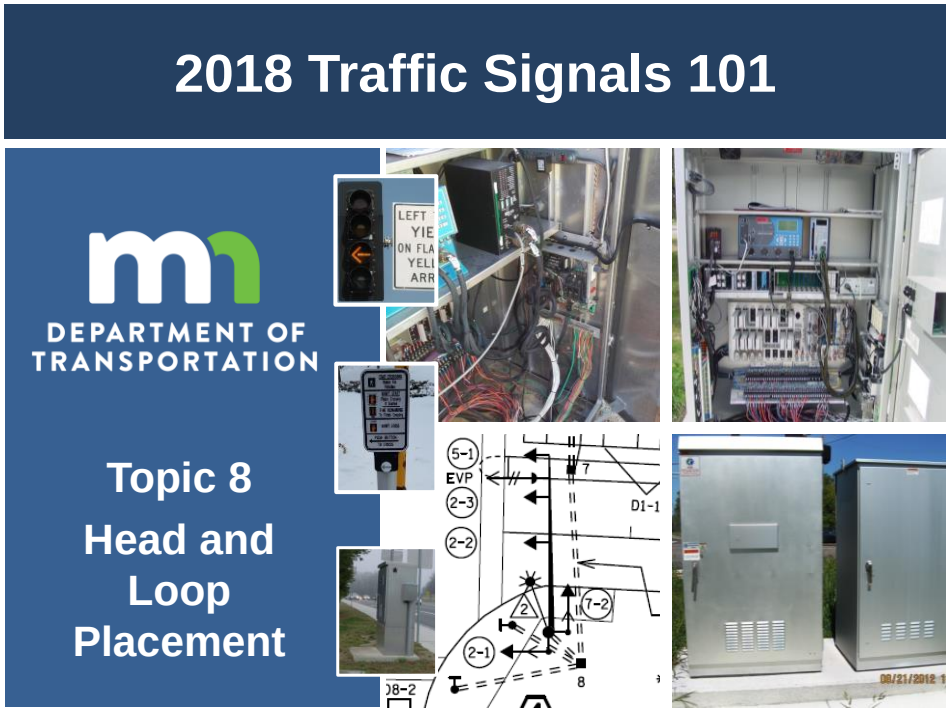
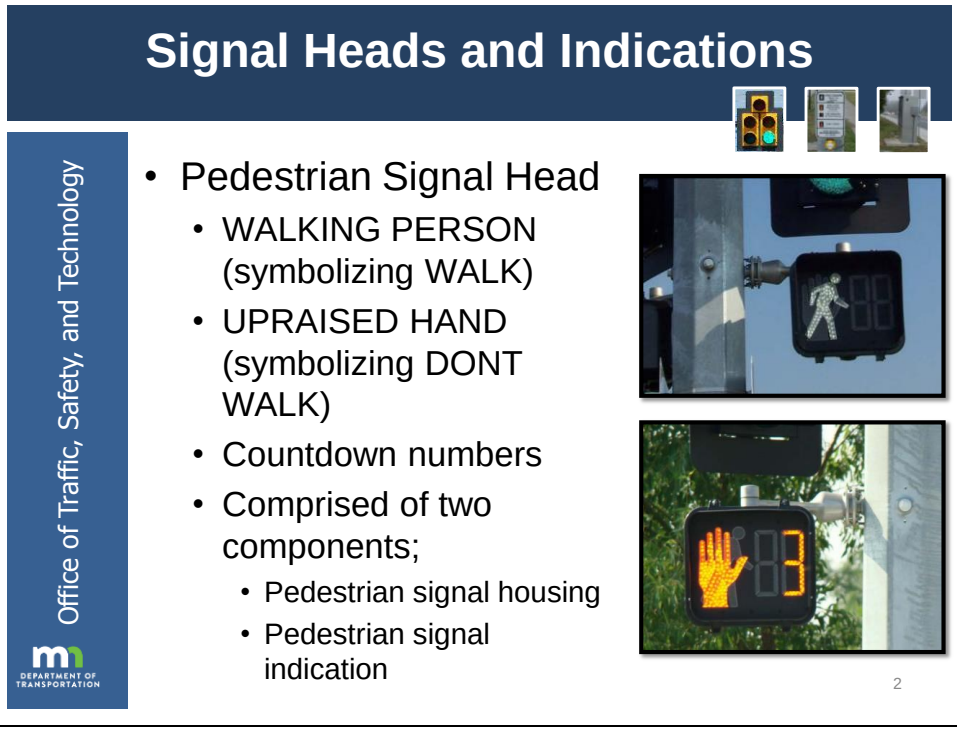
TOPIC 8: HEAD AND LOOP PLACEMENT



In this topic you will be introduced to traffic signal head placement and vehicle loop detector placement. A series of detector and head placement charts are included at the back of this topic. These are found in the Signal Design Manual.



The following definitions are adapted from the 2014 version of the MnMUTCD.

Section 1A.

Pedestrian Signal Head

A pedestrian signal head, which contains the symbols WALKING PERSON (symbolizing WALK) and, UPRAISED HAND (symbolizing DONT WALK) and countdown numbers that is installed to direct pedestrian traffic at a traffic control signal. The head is comprised of two components; a pedestrian signal housing and a pedestrian signal indication that fits within the housing

Signal Heads and Indications

Office of Traffic, Safety, and Technology

- Pedestrian Signal Housing
  - Protects the light source and other components
  - Indication mounting door and sun visor
- Pedestrian Signal Indication
  - LED hand and man countdown indication module that is installed within the pedestrian signal housing

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Pedestrian Signal Housing

Polycarbonate housing that protects the light source and other required components. The housing includes an indication mounting door and sun visor.

Pedestrian Signal Indication

Light Emitting Diode (LED) hand and man countdown indication module that is installed within the pedestrian signal housing.

Signal Heads and Indications

Office of Traffic, Safety, and Technology

- Vehicle Signal Head
  - Is an assembly of one or more signal sections that is provided for controlling vehicle traffic movements on one or more approaches
  - This assembly of signal sections also includes a background shield

4

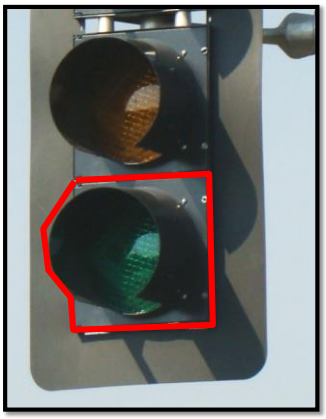
Vehicle Signal Head

Is an assembly of one or more signal sections that is provided for controlling vehicle traffic movements on one or more approaches. This assembly of signal sections also includes a background shield.

Signal Heads and Indications

Office of Traffic, Safety, and Technology

- Signal Section
  - Assembly of a signal housing, signal lens, if any, and light source with necessary components to be used for displaying one signal indication
  - Section is comprised of two components
    - Signal housing
    - Signal indication



5

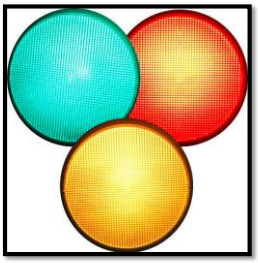
Signal Section

The assembly of a signal housing, signal lens, if any, and light source with necessary components to be used for displaying one signal indication. The section is comprised of two components; a signal housing and a signal indication that fits within the housing.

Signal Heads and Indications

Office of Traffic, Safety, and Technology

- Signal Housing
  - Protects the light source and other required components
  - Includes a hinged opening (with visor) in which the signal indication is mounted
- Signal Indication
  - Is the illumination of a signal lens or equivalent device
  - Light Emitting Diode (LED) indication module
  - Installed within the signal housing
- Housing and indication make up the section



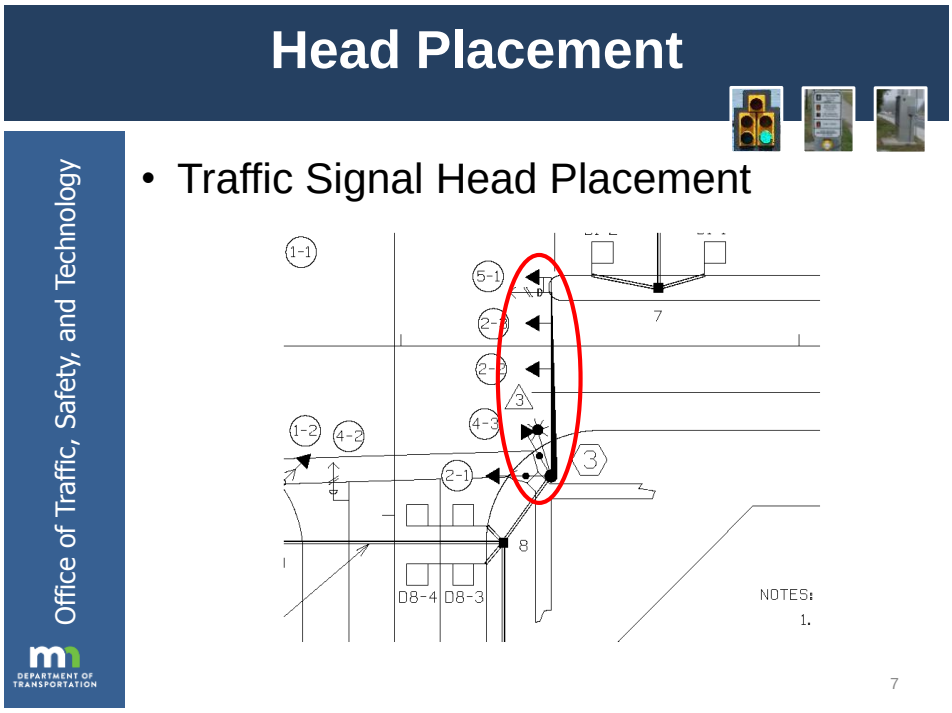
6

Signal Housing

That part of a signal section that protects the light source and other required components. Polycarbonate housing that protects the light source and other required components and includes a hinged opening (with visor) in which the signal indication is mounted. This is one of two components that make up a signal section.

Signal Indication

Is the illumination of a signal lens or equivalent device. The device is a Light Emitting Diode (LED) indication module that is installed within the signal housing. This is one of two components that make up a signal section.



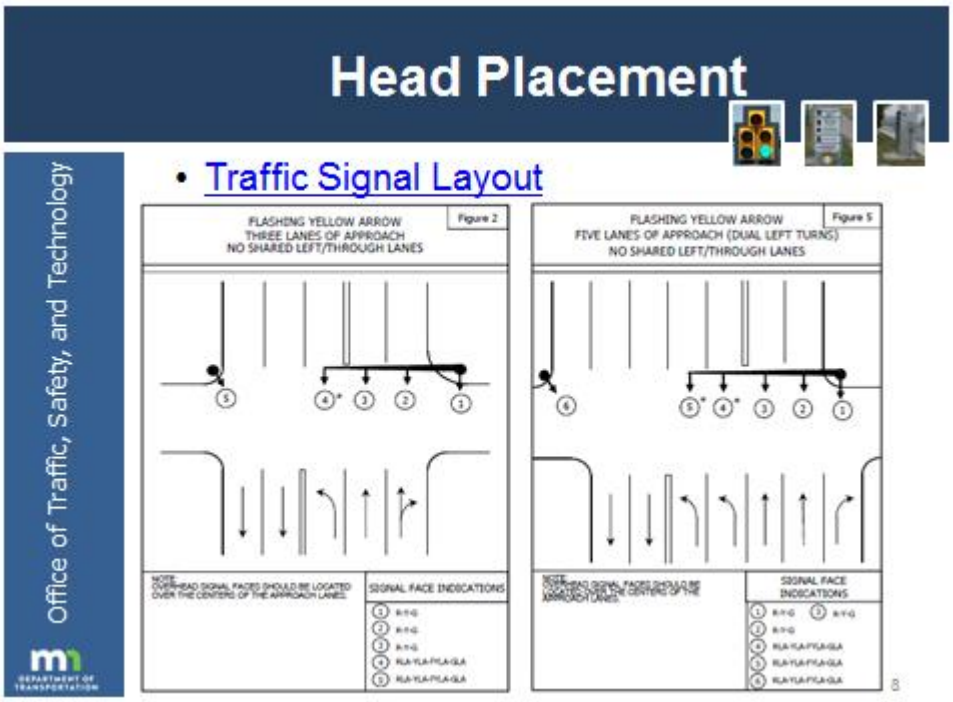
When placing signal heads:

- Consider signal operations
- Review noted information from field observations checklist (signal design)

Then refer to:

- Signal face layouts in the Signal Design Manual
- Standard plates and technical manual for symbols and,
- Uniform traffic signal plan labeling format (Signal Design Manual)

A filled in triangle indicates a new signal head, an open triangle indicates an existing signal head.



Sample signal head placement charts. Refer to the handouts at the back of this topic (from the Signal Design Manual).

These charts show the minimum number of signal heads.

There has to be more than one signal head.

These layouts are not definitive, and should be considered the minimum arrangements. These figures do not cover every possible condition; they may need to be adapted to fit the situation.

Loop Placement

Office of Traffic, Safety, and Technology

- Loop Detector Placement Design
  - Guaranteed Green
  - Safety
  - Failsafe
  - Maintenance
  - Operation

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Guaranteed Green. All vehicles except right turn on red (RTOR) vehicles will be guaranteed service of a green light within a cycle.

Safety. Consideration must be given to winter as well as summer conditions

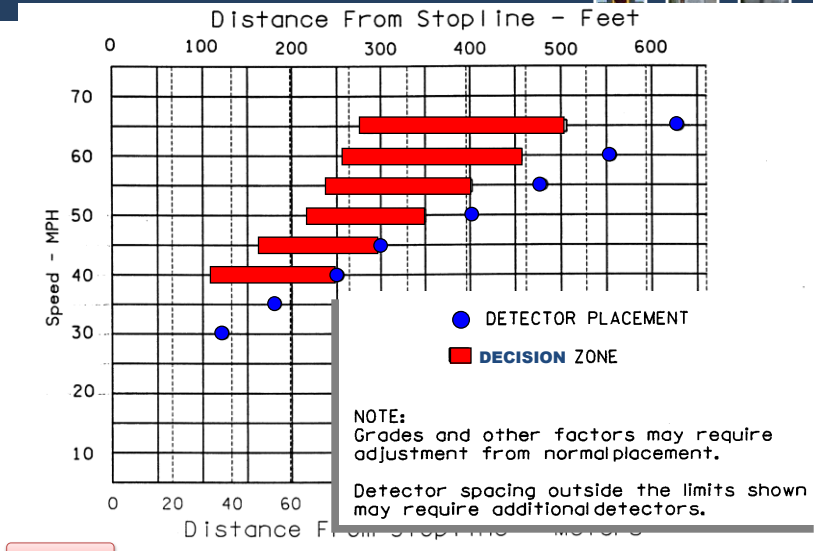
Failsafe. Alternatives must be provided for when a primary detector fails so that non-mainline phases don't have to be placed on recall.

Maintenance. Detectors should be located in a good roadbed, if the surface is in a very poor condition it should be replaced.

Operation. Detectors should provide operation that is logical to the driving public.

Loop Placement

Office of Traffic, Safety, and Technology



Animation

10

The horizontal bar indicates a range of distance out from the intersection, within which some drivers will, and some will not, stop for a yellow light. Detector placement allows the signal to change to yellow when this area near the intersection is empty of cars.

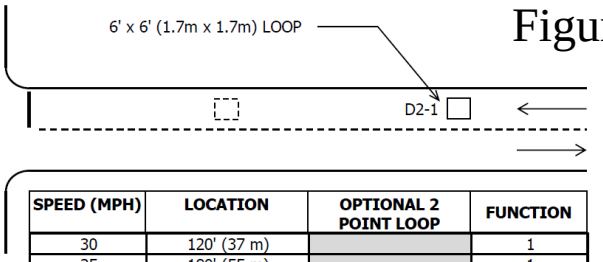
The decision zone is 2 to 4-1/2 seconds away from the stop bar.

Loop Placement

Office of Traffic, Safety, and Technology

DEPARTMENT OF TRANSPORTATION

Figure 1



SPEED (MPH)	LOCATION	OPTIONAL 2 POINT LOOP	FUNCTION
30	120' (37 m)		1
35	180' (55 m)		1
40	250' (76 m)		1
45	300' (92 m)		1
50	400' (122 m)		1
55	475' (145 m)	240' (75 m)	1
60*	550' (168 m)	275' (84 m)	1
65*	625' (191 m)	315' (96 m)	1

LOCATION = DISTANCE FROM STOP BAR TO LOOP DETECTOR
* ONLY APPLY TO DIVIDED 4-LANE ROADWAY

LOOP DETECTOR FUNCTIONS
1 = CALL AND EXTEND

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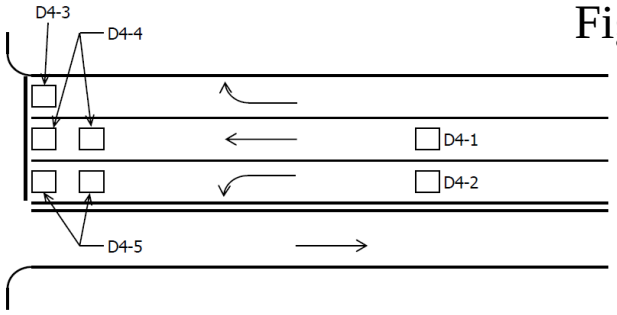
This is a typical detector placement for a loop on the major approach. There is no stop-line detector and the phase is placed on recall (the green is returned to this movement after servicing the conflicting movements).

Loop Placement

Office of Traffic, Safety, and Technology

DEPARTMENT OF TRANSPORTATION

Figure 2



LOCATION = DISTANCE FROM STOP BAR TO LOOP DETECTOR

SPEED (MPH)	LOCATION
30	120' (37 m)
35	180' (55 m)
40	250' (76 m)

LOOP DETECTOR FUNCTIONS
1 = CALL AND EXTEND
7 = DELAY CALL - IMMEDIATE EXTEND

NUMBER	FUNCTION	SIZE
D4-1	1	6' x 6' (1.7 x 1.7 m)
D4-2	1	6' x 6' (1.7 x 1.7 m)
D4-3	7	6' x 6' (1.7 x 1.7 m)
D4-4	1	2-6' x 6' (1.7 x 1.7 m)
D4-5	1	2-6' x 6' (1.7 x 1.7 m)

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Where the minor approach is low volume and low speed, the back detectors (D4-1 and D4-2) are sometimes omitted.

Handout

Excerpts from the Signal Design Manual, Chapter 3 and 4

For the latest version, please visit:

www.dot.state.mn.us/trafficeng/publ/index.html

3. HEAD PLACEMENT CHARTS

In this chapter, signal head placement charts are introduced starting on page 3-3. These charts are generally intended for new signal designs and may not be feasible for a rebuild/modification. If the design is a rebuild or modification, these charts can act as guidance, but the minimum requirements in the MN MUTCD must be followed.

The primary consideration in signal head placement is clear visibility. Drivers approaching an intersection shall be given a clear and unmistakable indication of their right-of-way assignment. The number and placement of signal heads shall conform to the requirements of the MN MUTCD. The size of lenses shall be as stated in the MN MUTCD. A handout of the MN MUTCD is included at the end of this chapter.

In general, vehicle signal heads should be placed and aimed to have maximum effectiveness for an approaching driver located a distance from the stop line equal to the distance traveled while reacting to the signal and bringing the vehicle to a stop at an average approach speed. Visors, shields, or visual delimiting should be used to help in directing the signal indication to the approaching traffic, and to reduce sun phantom resulting from external light entering a signal lens.

A red ball or arrow indication is a directive to drivers that they must not enter the intersection. A yellow ball or arrow indication is a change interval and a notice to drivers that they may enter the intersection only if they are too close to safely/comfortably stop. A green arrow informs drivers that they have an unrestricted (by vehicles and pedestrians) movement and may enter the intersection. A green ball indication informs drivers that they may make a permitted left, through or right movement while yielding to conflicting vehicles and pedestrians. 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.

The signal head layouts on the following pages are not definitive, and should be considered the minimum arrangements. These figures do not cover every possible condition; they may need to be adapted to fit the situation.

Horizontally arranged and vertically arranged signal heads may be used on the same approach provided they are separated to meet the lateral separation spacing required in Section 4D of the MN MUTCD (see the end of this chapter).

As discussed in Chapter 2, a FYA indication is required for all dedicated left turn lanes for all state highways, with the exceptions described in the Traffic Engineering Manual, Chapter 9.

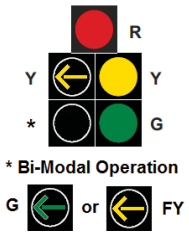
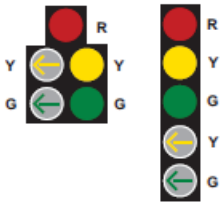
The figures are divided into four sections as follows:

- Flashing Yellow Arrow signal head arrangements with no shared left/through lanes (Section 3.1)
- Flashing Yellow Arrow signal head arrangements with shared left/through lanes (Section 3.2)
- Low Speed non-Flashing Yellow Arrow (Section 3.3)
- High speed non-Flashing Yellow Arrow (Section 3.4)
    - High speed is considered to be 45 mph and above.

An important note in the MN MUTCD, Section 4D.13 states:

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

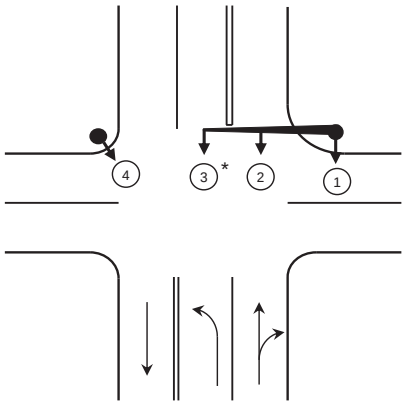
The following abbreviations are used in the figures in this chapter:

Abbreviation	Description	Arrangement
R-Y-G	Three-Section Red, Yellow, Green Ball	
RLA-YLA-FYLA-GLA	Four-Section Red, Yellow, Green Left Turn Arrow and Flashing Yellow Left Turn Arrow *Note: The FYA is required on dedicated left turn lanes per the TEM. See Section **2.3.3** for information*	 * Shall not be displayed when operating in the protected only mode
RLA-YLA-GLA	Three-Section Red, Yellow Green Left Turn Arrow	
R-Y-G-YLA-FYLA-GLA This is also referred to as a 5-section "doghouse" head with a bi-modal arrow selection. It does have 5 signal heads with 6 possible intervals since the lower left indication can be a solid green or flashing yellow.	Five-Section Red, Yellow, Green Ball and Yellow, bi-modal Green Left Turn Arrow/Flashing Yellow Left Turn Arrow ** Note: The lower left indication is a bi-modal left turn arrow will be a solid green arrow or flashing yellow left turn arrow.*	 * Bi-Modal Operation G or FY
R-Y-G-YLA-GLA	Five-Section Red, Yellow, Green Ball and Yellow, Green Left Turn Arrow *Note: If used, signal indication should not be within the extended lane lines of an exclusive left turn (see MN MUTCD Section 4D.13*	

3.1 FLASHING YELLOW ARROW CHARTS (NO SHARED LEFT/THROUGH LANES)

Figure 1

FLASHING YELLOW ARROW
TWO LANES OF APPROACH
NO SHARED LEFT/THROUGH LANES



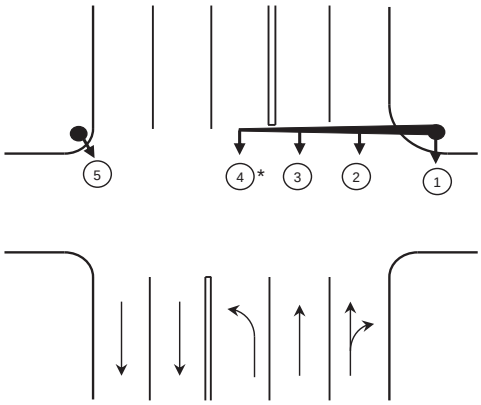
NOTE:
OVERHEAD SIGNAL FACES SHOULD BE LOCATED OVER THE CENTERS OF THE APPROACH LANES.

SIGNAL FACE INDICATIONS

1. R-Y-G
2. R-Y-G
3. RLA-YLA-FYLA-GLA
4. RLA-YLA-FYLA-GLA

Figure 2

FLASHING YELLOW ARROW
THREE LANES OF APPROACH
NO SHARED LEFT/THROUGH LANES



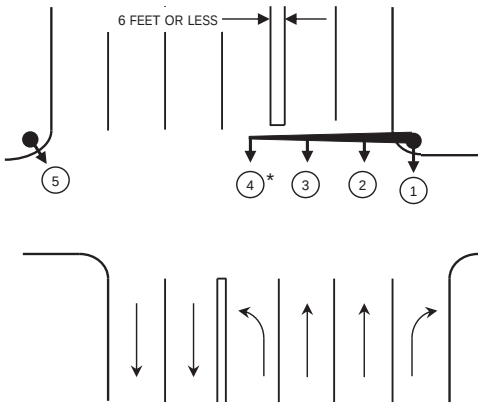
NOTE:
OVERHEAD SIGNAL FACES SHOULD BE LOCATED OVER THE CENTERS OF THE APPROACH LANES.

SIGNAL FACE INDICATIONS

1. R-Y-G
2. R-Y-G
3. R-Y-G
4. RLA-YLA-FYLA-GLA
5. RLA-YLA-FYLA-GLA

Figure 3

FLASHING YELLOW ARROW
FOUR LANES OF APPROACH
NO SHARED LEFT/THROUGH LANES



NOTE:
OVERHEAD SIGNAL FACES SHALL BE LOCATED OVER THE CENTERS OF THE APPROACH LANES.

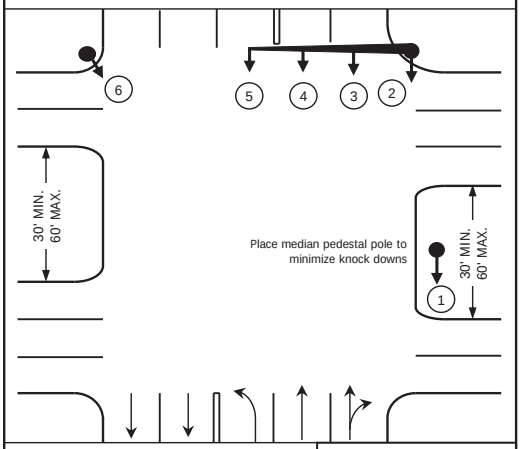
IF THREE OR MORE THRU LANES, ANOTHER SIGNAL FACE SHOULD BE PLACED OVER THE GIVEN LANE.

SIGNAL FACE INDICATIONS

1. R-Y-G
2. R-Y-G
3. R-Y-G
4. RLA-YLA-FYLA-GLA
5. RLA-YLA-FYLA-GLA

Figure 4

FLASHING YELLOW ARROW
THREE LANES OF APPROACH (DIVIDED HIGHWAY)
NO SHARED LEFT/THROUGH LANES



NOTE:
OVERHEAD SIGNAL FACES SHOULD BE LOCATED OVER THE CENTERS OF THE APPROACH LANES.

SIGNAL FACE NO. 1 SHOULD BE A PEDESTAL MOUNTED SIGNAL INDICATION

SIGNAL FACE NO. 2 IS OPTIONAL

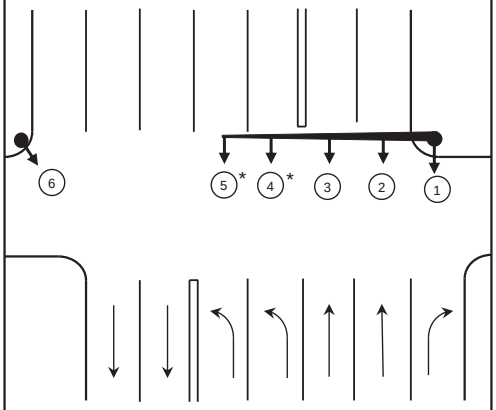
SIGNAL FACE INDICATIONS

1. R-Y-G
2. R-Y-G
3. R-Y-G
4. R-Y-G
5. RLA-YLA-FYLA-GLA
6. RLA-YLA-FYLA-GLA

* ensure that opposing left turn heads do not block each other

Figure 5

FLASHING YELLOW ARROW
FIVE LANES OF APPROACH (DUAL LEFT TURNS)
NO SHARED LEFT/THROUGH LANES

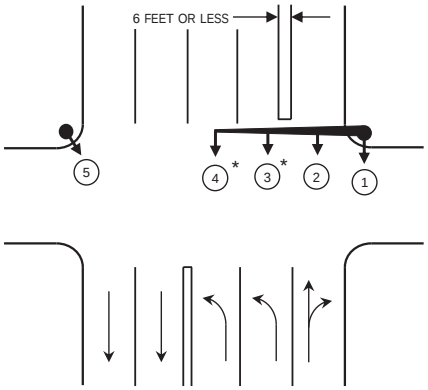


NOTE:
OVERHEAD SIGNAL FACES SHOULD BE LOCATED OVER THE CENTERS OF THE APPROACH LANES.

SIGNAL FACE INDICATIONS	
1 R-Y-G	3 R-Y-G
2 R-Y-G	
4 RLA-YLA-FYLA-GLA	
5 RLA-YLA-FYLA-GLA	
6 RLA-YLA-FYLA-GLA	

Figure 6

FLASHING YELLOW ARROW
THREE LANES OF APPROACH
NO SHARED LEFT/THROUGH LANES

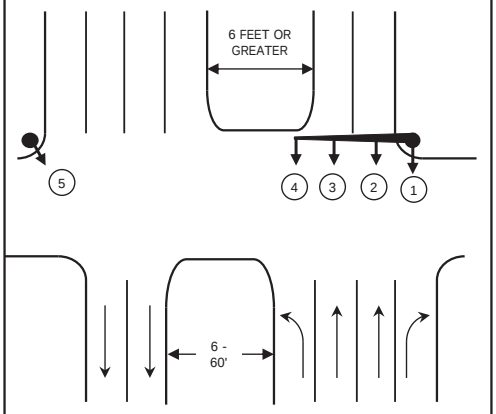


NOTE:
OVERHEAD SIGNAL FACES SHOULD BE LOCATED OVER THE CENTER OF THE APPROACH LANES.

SIGNAL FACE INDICATIONS
1 R-Y-G
2 R-Y-G
3 RLA-YLA-FYLA-GLA
4 RLA-YLA-FYLA-GLA
5 RLA-YLA-FYLA-GLA

Figure 7

FLASHING YELLOW ARROW
FOUR LANES OF APPROACH (WIDE MEDIAN)
NO SHARED LEFT/THROUGH LANES



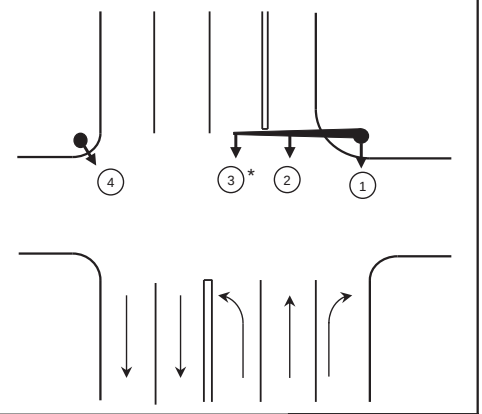
NOTE:
OVERHEAD SIGNAL FACES SHOULD BE LOCATED OVER THE CENTERS OF THE APPROACH LANES.

A PEDESTAL MOUNTED SIGNAL INDICATION MAY BE USED INPLACE OF OVERHEAD SIGNAL FACE NO. 4.

SIGNAL FACE INDICATIONS	
1 R-Y-G	3 R-Y-G
2 R-Y-G	
4 RLA-YLA-FYLA-GLA	
5 RLA-YLA-FYLA-GLA	

Figure 8

FLASHING YELLOW ARROW
THREE LANES OF APPROACH (EXCLUSIVE RIGHT)
NO SHARED LEFT/THROUGH LANES



NOTE:
OVERHEAD SIGNAL FACE NO. 2 SHOULD BE LOCATED OVER THE CENTER OF THE THROUGH LANE.

OVERHEAD SIGNAL FACE NO. 3 SHOULD BE LOCATED OVER THE CENTER OF THE LEFT TURN LANE.

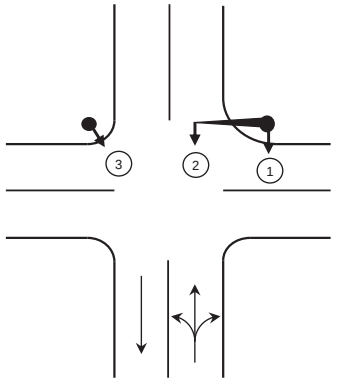
SIGNAL FACE INDICATIONS
1 R-Y-G
2 R-Y-G
3 RLA-YLA-FYLA-GLA
4 RLA-YLA-FYLA-GLA

* ensure that opposing left turn heads do not block each other

3.2 FLASHING YELLOW ARROW CHARTS (WITH SHARED LEFT/THROUGH LANES) – OPTIONAL CHARTS

Figure 9

FLASHING YELLOW ARROW
SINGLE LANE OF APPROACH
WITH SHARED LEFT THROUGH LANE(S)



NOTE:
OVERHEAD SIGNAL FACE NO. 2 SHOULD BE LOCATED OVER THE CENTER OF THE THROUGH LANE.

DUE TO OPERATIONAL LIMITATIONS, REFER TO THE SIGNAL TIMING AND OPTIMZATION MANUAL FOR THE OPERATION OF THE FYA.

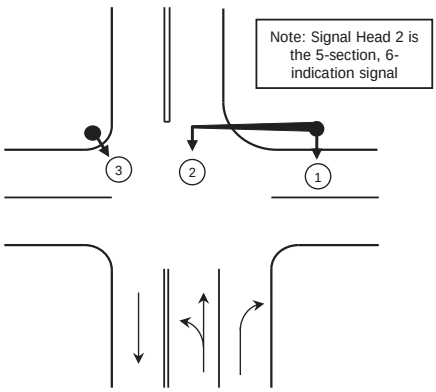
SIGNAL FACES 2 AND 3 ARE THE 5-SECTION BI-MODAL SIGNAL INDICATIONS.

SIGNAL FACE INDICATIONS

1. R-Y-G
2. R-Y-G-YLA-FYLA-GLA
3. R-Y-G-YLA-FYLA-GLA

Figure 10

FLASHING YELLOW ARROW
TWO LANES OF APPROACH (EXCLUSIVE RIGHT)
WITH SHARED LEFT THROUGH LANE(S)



NOTE:
OVERHEAD SIGNAL FACES SHOULD BE LOCATED OVER THE CENTERS OF THE APPROACH LANES.

DUE TO OPERATIONAL LIMITATIONS, REFER TO THE SIGNAL TIMING AND OPTIMZATION MANUAL FOR THE OPERATION OF THE FYA.

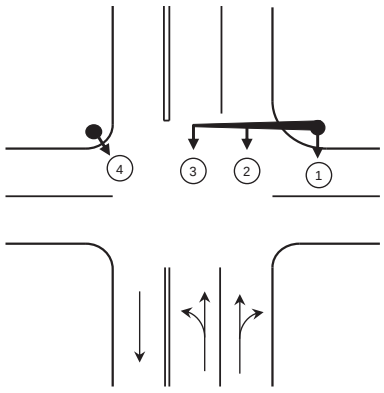
SIGNAL FACES 2 AND 3 ARE THE 5-SECTION BI-MODAL SIGNAL INDICATIONS.

SIGNAL FACE INDICATIONS

1. R-Y-G
2. R-Y-G-YLA-FYLA-GLA
3. R-Y-G-YLA-FYLA-GLA

Figure 11

FLASHING YELLOW ARROW
TWO LANES OF APPROACH
WITH SHARED LEFT THROUGH LANE(S)



NOTE:
OVERHEAD SIGNAL FACES SHOULD BE LOCATED OVER THE CENTERS OF THE APPROACH LANES.

DUE TO OPERATIONAL LIMITATIONS, REFER TO THE SIGNAL TIMING AND OPTIMZATION MANUAL FOR THE OPERATION OF THE FYA.

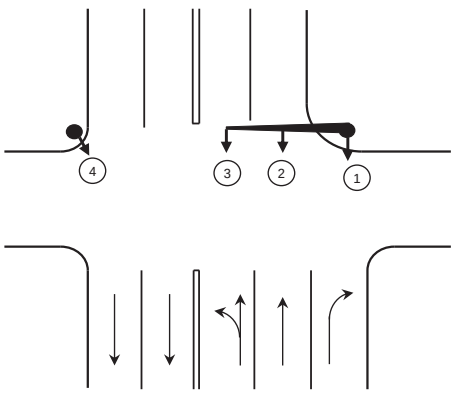
SIGNAL FACES 3 AND 4 ARE THE 5-SECTION BI-MODAL SIGNAL INDICATIONS.

SIGNAL FACE INDICATIONS

1. R-Y-G
2. R-Y-G
3. R-Y-G-YLA-FYLA-GLA
4. R-Y-G-YLA-FYLA-GLA

Figure 12

FLASHING YELLOW ARROW
THREE LANES OF APPROACH (EXCLUSIVE RIGHT)
WITH SHARED LEFT THROUGH LANE(S)



NOTE:
OVERHEAD SIGNAL FACES SHOULD BE LOCATED OVER THE CENTERS OF THE APPROACH LANES.

DUE TO OPERATIONAL LIMITATIONS, REFER TO THE SIGNAL TIMING AND OPTIMZATION MANUAL FOR THE OPERATION OF THE FYA.

SIGNAL FACES 3 AND 4 ARE THE 5-SECTION BI-MODAL SIGNAL INDICATIONS.

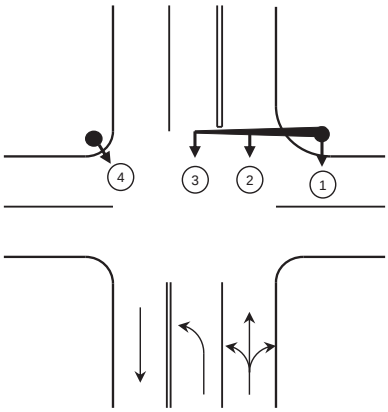
SIGNAL FACE INDICATIONS

1. R-Y-G
2. R-Y-G
3. R-Y-G-YLA-FYLA-GLA
4. R-Y-G-YLA-FYLA-GLA

NOTE: FYA should not be used if opposing left turn vehicle paths overlap.

Figure 13

FLASHING YELLOW ARROW
TWO LANES OF APPROACH (EXCLUSIVE LEFT)
WITH SHARED LEFT THROUGH LANE(S)



NOTE:
OVERHEAD SIGNAL FACES SHOULD BE LOCATED OVER THE CENTERS OF THE APPROACH LANES.

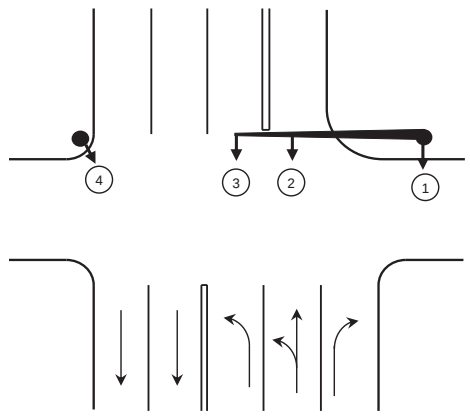
DUE TO OPERATIONAL LIMITATIONS, REFER TO THE SIGNAL TIMING AND OPTIMZATION MANUAL FOR THE OPERATION OF THE FYA.

SIGNAL FACE 2 IS THE 5-SECTION BI-MODAL SIGNAL INDICATION.

SIGNAL FACE INDICATIONS	
1	R-Y-G
2	R-Y-G-YLA-FYLA-GLA
3	RLA-YLA-FYLA-GLA
4	RLA-YLA-FYLA-GLA

Figure 14

FLASHING YELLOW ARROW
THREE LANES OF APPROACH (EXCLUSIVE RIGHT)
WITH SHARED LEFT THROUGH LANE(S)



NOTE:
OVERHEAD SIGNAL FACES SHOULD BE LOCATED OVER THE CENTERS OF THE APPROACH LANES.

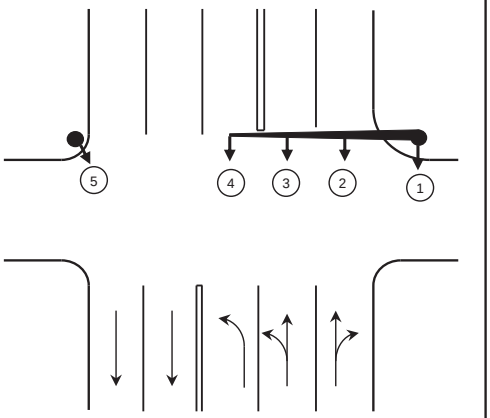
DUE TO OPERATIONAL LIMITATIONS, REFER TO THE SIGNAL TIMING AND OPTIMZATION MANUAL FOR THE OPERATION OF THE FYA.

SIGNAL FACE 2 IS THE 5-SECTION BI-MODAL SIGNAL INDICATION.

SIGNAL FACE INDICATIONS	
1	R-Y-G
2	R-Y-G-YLA-FYLA-GLA
3	RLA-YLA-FYLA-GLA
4	RLA-YLA-FYLA-GLA

Figure 15

FLASHING YELLOW ARROW
THREE LANES OF APPROACH (EXCLUSIVE LEFT)
WITH SHARED LEFT THROUGH LANE(S)



NOTE:
OVERHEAD SIGNAL FACES SHOULD BE LOCATED OVER THE CENTERS OF THE APPROACH LANES.

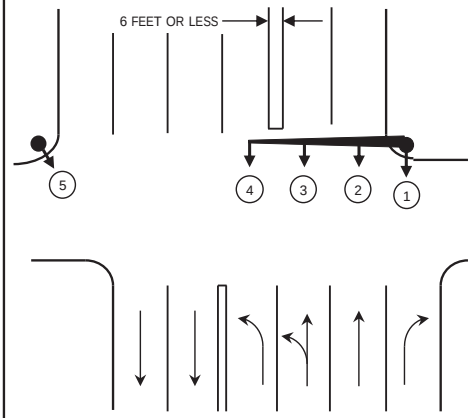
DUE TO OPERATIONAL LIMITATIONS, REFER TO THE SIGNAL TIMING AND OPTIMZATION MANUAL FOR THE OPERATION OF THE FYA.

SIGNAL FACE 3 IS THE 5-SECTION BI-MODAL SIGNAL INDICATION.

SIGNAL FACE INDICATIONS	
1	R-Y-G
2	R-Y-G
3	R-Y-G-YLA-FYLA-GLA
4	RLA-YLA-FYLA-GLA
5	RLA-YLA-FYLA-GLA

Figure 16

FLASHING YELLOW ARROW
FOUR LANES OF APPROACH (EXCLUSIVE LEFT/RIGHT)
WITH SHARED LEFT THROUGH LANE(S)



NOTE:
OVERHEAD SIGNAL FACES SHALL BE LOCATED OVER THE CENTERS OF THE APPROACH LANES.

IF THREE OR MORE THRU LANES, ANOTHER SIGNAL FACE SHOULD BE PLACED OVER THE GIVEN LANE.

DUE TO OPERATIONAL LIMITATIONS, REFER TO THE SIGNAL TIMING AND OPTIMZATION MANUAL FOR THE OPERATION OF THE FYA.

SIGNAL FACE 3 IS THE 5-SECTION BI-MODAL

SIGNAL FACE INDICATIONS	
1	R-Y-G
2	R-Y-G
3	R-Y-G-YLA-FYLA-GLA
4	RLA-YLA-FYLA-GLA
5	RLA-YLA-FYLA-GLA

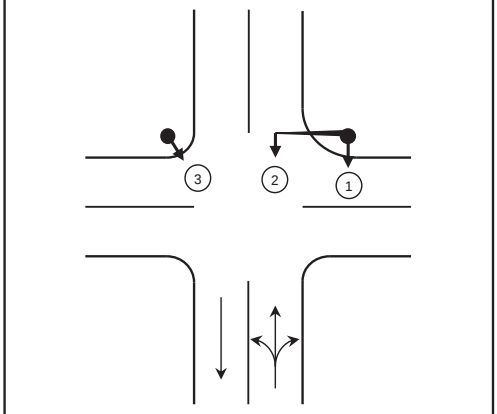
NOTE: FYA should not be used if opposing left turn vehicle paths overlap.

3.3 LOW SPEED (NON-FLASHING YELLOW ARROW) CHARTS

Note: The preferred charts are found in Section 3.1 and 3.2. These are maintained for legacy purposes.

Figure 17

SINGLE LANE OF APPROACH
LOW SPEEDS



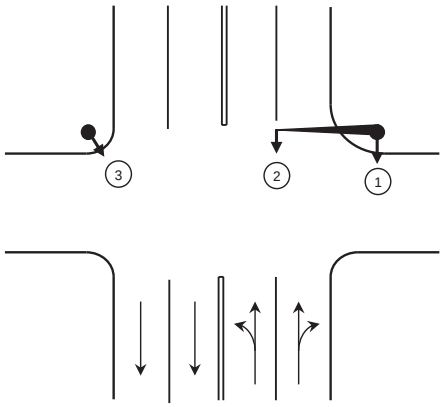
NOTE:
OVERHEAD SIGNAL FACE NO. 2 SHOULD BE LOCATED OVER THE CENTER OF THE THROUGH LANE.

SIGNAL FACE INDICATIONS

1 R-Y-G
2 R-Y-G
3 R-Y-G

Figure 18

TWO LANES OF APROACH
LOW SPEEDS



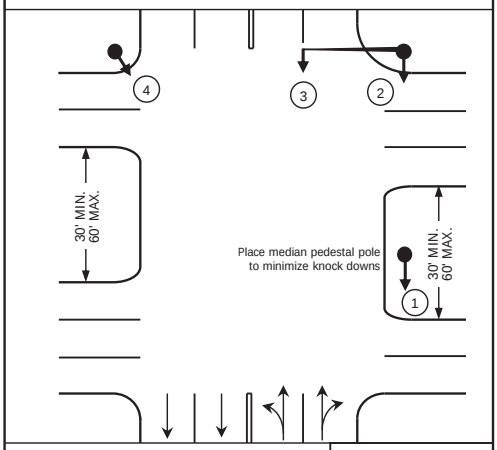
NOTE:
OVERHEAD SIGNAL FACE NO. 2 SHOULD BE LOCATED OVER THE LANE LINE.

SIGNAL FACE INDICATIONS

1 R-Y-G
2 R-Y-G
3 R-Y-G

Figure 19

TWO LANES OF APPROACH (DIVIDED HIGHWAY)
LOW SPEEDS



NOTE:
OVERHEAD SIGNAL FACE NO. 3 SHOULD BE LOCATED OVER THE LANE LINE.

SIGNAL FACE NO. 1 SHOULD BE A PEDESTAL MOUNTED SIGNAL INDICATION

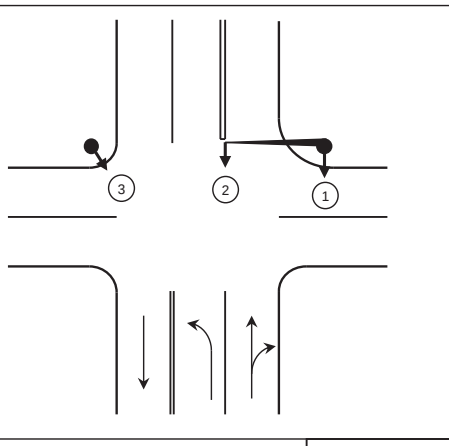
SIGNAL FACE NO. 2 IS OPTIONAL

SIGNAL FACE INDICATIONS

1 R-Y-G
2 R-Y-G
3 R-Y-G
4 R-Y-G

Figure 20

PROTECTED/PERMISSIVE LEFT TURN
TWO LANES OF APPROACH
LOW SPEEDS



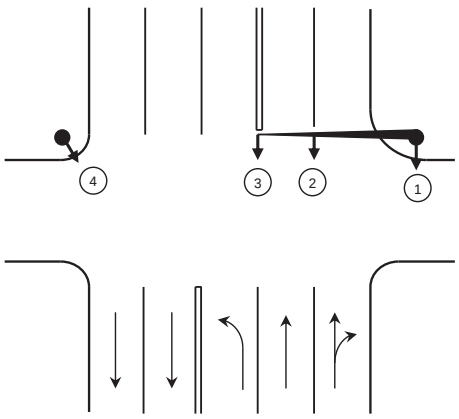
NOTE:
OVERHEAD SIGNAL SHOULD BE LOCATED OVER THE LANE LINE.

SIGNAL FACE INDICATIONS

1 R-Y-G
2 R-Y-G-YLA-GLA
3 R-Y-G-YLA-GLA

Figure 21

PROTECTED/PERMISSIVE LEFT TURN
THREE LANES OF APPROACH
LOW SPEEDS

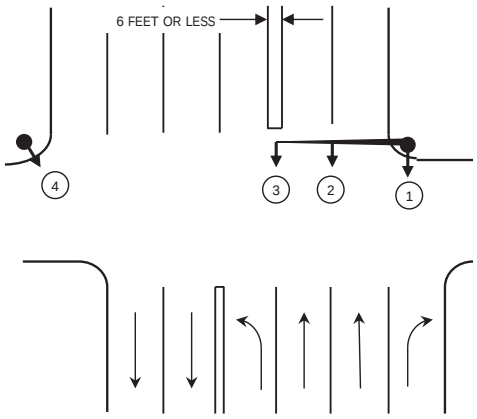


NOTE:
OVERHEAD SIGNAL FACES SHOULD BE LOCATED OVER THE LANE LINES

SIGNAL FACE INDICATIONS	
1	R-Y-G
2	R-Y-G
3	R-Y-G-YLA-GLA
4	R-Y-G-YLA-GLA

Figure 22

PROTECTED/PERMISSIVE LEFT TURN
FOUR LANES OF APPROACH
LOW SPEEDS



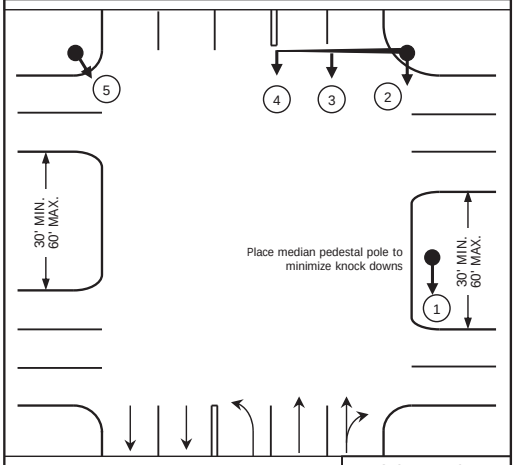
NOTE:
OVERHEAD SIGNAL FACES SHOULD BE LOCATED OVER THE LANE LINES.

IF THREE OR MORE THRU LANES, ANOTHER SIGNAL FACE SHOULD BE PLACED OVER THE GIVEN LANE LINE.

SIGNAL FACE INDICATIONS	
1	R-Y-G
2	R-Y-G
3	R-Y-G-YLA-GLA
4	R-Y-G-YLA-GLA

Figure 23

PROTECTED/PERMISSIVE LEFT TURN
THREE LANES OF APPROACH (DIVIDED HIGHWAY)



NOTE:
OVERHEAD SIGNAL FACES SHOULD BE LOCATED OVER THE LANE LINES.

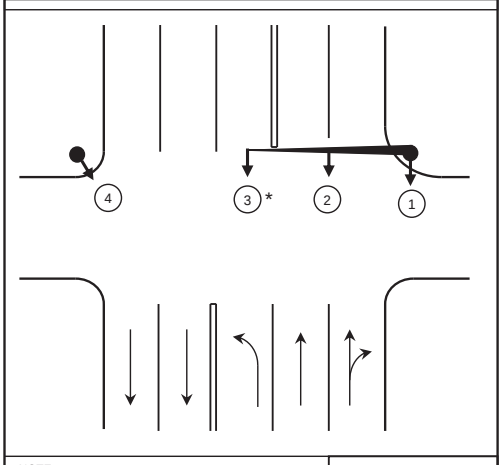
SIGNAL FACE NO. 1 SHOULD BE A PEDESTAL MOUNTED SIGNAL INDICATION

SIGNAL FACE NO. 2 IS OPTIONAL

SIGNAL FACE INDICATIONS	
1	R-Y-G
2	R-Y-G
3	R-Y-G
4	R-Y-G-YLA-GLA
5	R-Y-G-YLA-GLA

Figure 24

PROTECTED LEFT TURN
THREE LANES OF APPROACH
LOW SPEEDS



NOTE:
OVERHEAD SIGNAL FACE NO. 2 SHOULD BE LOCATED OVER THE LANE LINE.

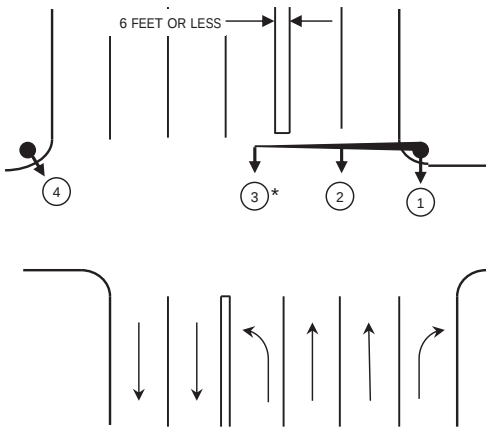
OVERHEAD SIGNAL FACE NO. 3 SHOULD BE LOCATED OVER THE CENTER OF THE LEFT TURN LANE.

SIGNAL FACE INDICATIONS	
1	R-Y-G
2	R-Y-G
3	RLA-YLA-GLA
4	RLA-YLA-GLA

* ensure that opposing left turn heads do not block each other

Figure 25

PROTECTED LEFT TURN
FOUR LANES OF APPROACH
LOW SPEEDS



NOTE:
OVERHEAD SIGNAL FACE NO. 2 SHOULD BE LOCATED OVER THE LANE LINE.

OVERHEAD SIGNAL FACE NO. 3 SHOULD BE LOCATED OVER THE CENTER OF THE LEFT TURN LANE.

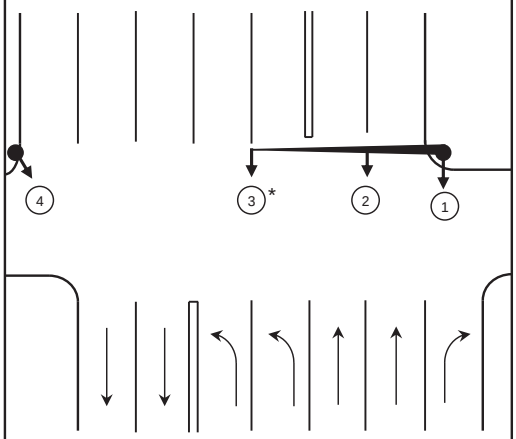
IF THREE OR MORE THRU LANES, ANOTHER SIGNAL FACE SHOULD BE PLACED OVER THE GIVEN LANE LINE.

SIGNAL FACE INDICATIONS

1. R-Y-G
2. R-Y-G
3. RLA-YLA-GLA
4. RLA-YLA-GLA

Figure 26

PROTECTED LEFT TURN
FIVE LANES OF APPROACH (DUAL LEFT TURNS)
LOW SPEEDS



NOTE:
OVERHEAD SIGNAL FACE NO. 2 SHOULD BE LOCATED OVER THE LANE LINE.

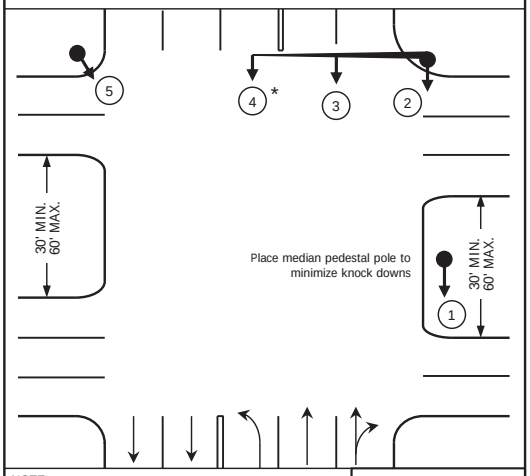
OVERHEAD SIGNAL FACE NO. 3 SHOULD BE LOCATED OVER THE LEFT TURN LANE LINES

SIGNAL FACE INDICATIONS

1. R-Y-G
2. R-Y-G
3. RLA-YLA-GLA
4. RLA-YLA-GLA

Figure 27

PROTECTED LEFT TURN
THREE LANES OF APPROACH (DIVIDED HIGHWAY)
LOW SPEEDS



NOTE:
OVERHEAD SIGNAL FACE NO. 3 SHOULD BE LOCATED OVER THE LANE LINE.

OVERHEAD SIGNAL FACE NO. 4 SHOULD BE LOCATED OF THE CENTER OF THE LEFT TURN LANE.

SIGNAL FACE NO. 1 SHOULD BE A PEDESTAL MOUNTED SIGNAL INDICATION.

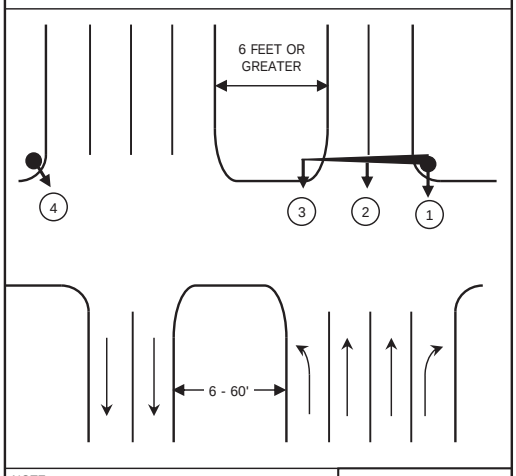
SIGNAL FACE NO. 2 IS OPTIONAL.

SIGNAL FACE INDICATIONS

1. R-Y-G
2. R-Y-G
3. R-Y-G
4. RLA-YLA-GLA
5. RLA-YLA-GLA

Figure 28

PROTECTED LEFT TURN
FOUR LANES OF APPROACH (WIDE MEDIAN)
LOW SPEEDS



NOTE:
OVERHEAD SIGNAL FACE NO. 2 SHOULD BE LOCATED OVER THE LANE LINE.

OVERHEAD SIGNAL FACE NO. 3 SHOULD BE LOCATED OVER THE CENTER OF THE LEFT TURN LANE.

A PEDESTAL MOUNTED SIGNAL INDICATION MAY BE USED INPLACE OF OVERHEAD SIGNAL FACE NO. 3.

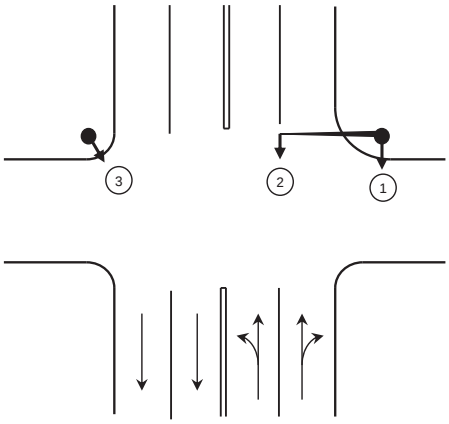
SIGNAL FACE INDICATIONS

1. R-Y-G
2. R-Y-G
3. RLA-YLA-GLA
4. RLA-YLA-GLA

* ensure that opposing left turn heads do not block each other

Figure 29

CROSS STREET SEQUENTIAL PHASING
TWO LANES OF APPROACH
LOW SPEEDS



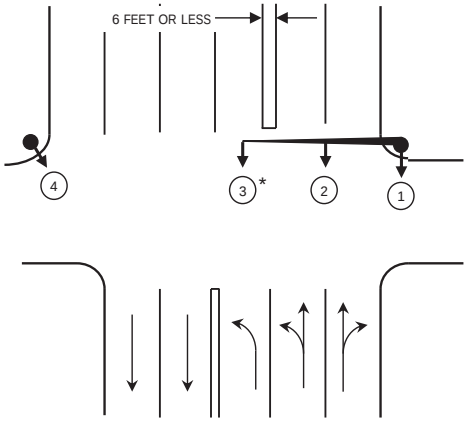
NOTE:
OVERHEAD SIGNAL FACE NO. 2 SHOULD BE LOCATED OVER THE LANE LINE.

SIGNAL FACE INDICATIONS

1 R-Y-G
2 R-Y-G-GLA
3 R-YLA-GLA

Figure 30

CROSS STREET SEQUENTIAL PHASING
THREE LANES OF APPROACH
LOW SPEEDS



NOTE:
OVERHEAD SIGNAL FACE NO. 2 SHOULD BE LOCATED OVER THE LANE LINE.

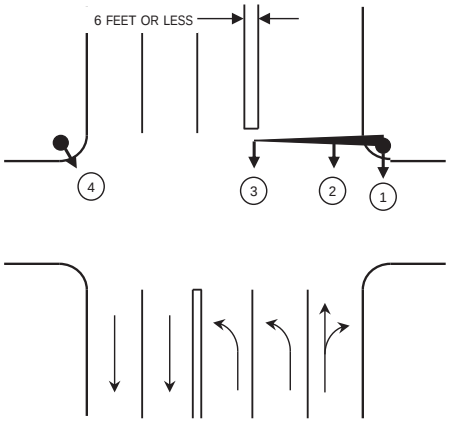
OVERHEAD SIGNAL FACE NO. 3 SHOULD BE LOCATED OVER THE CENTER OF THE LEFT TURN LANE.

SIGNAL FACE INDICATIONS

1 R-Y-G
2 R-Y-G
3 R-YLA-GLA
4 R-YLA-GLA

Figure 31

CROSS STREET SEQUENTIAL PHASING
THREE LANES OF APPROACH
LOW SPEEDS



NOTE:
OVERHEAD SIGNAL FACE NO. 2 SHOULD BE LOCATED OVER THE CENTER OF THE APPROACH LANE.

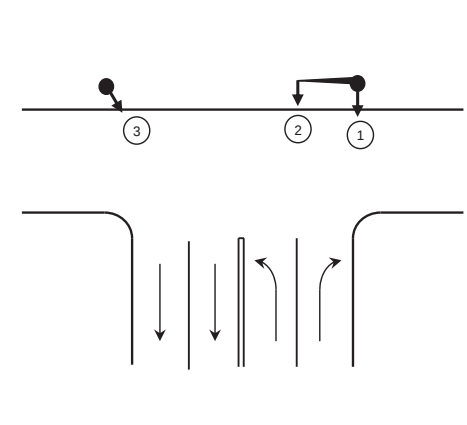
OVERHEAD SIGNAL FACE NO. 3 SHOULD BE LOCATED OVER THE LANE LINE BETWEEN THE LEFT TURN LANES.

SIGNAL FACE INDICATIONS

1 R-Y-G
2 R-Y-G
3 R-YLA-GLA
4 R-YLA-GLA

Figure 32

T-INTERSECTIONS
LOW SPEEDS



NOTE:
OVERHEAD SIGNAL FACE SHOULD BE LOCATED OVER THE LANE LINE.
NO PEDS PRESENT:
1 R-Y-G
2 R-Y-G-GLA
3 R-YLA-GLA

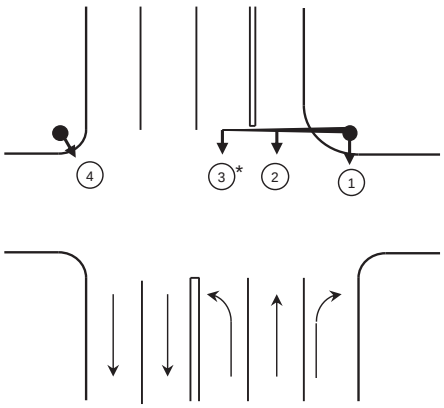
SIGNAL FACE INDICATIONS

1 R-Y-G
2 R-Y-G
3 R-Y-G
PEDS PRESENT

* ensure that opposing left turn heads do not block each other

Figure 33

PROTECTED LEFT TURN
THREE LANES OF APPROACH (EXCLUSIVE RIGHT)
LOW SPEEDS



NOTE:
OVERHEAD SIGNAL FACE NO. 2 SHOULD BE LOCATED OVER THE CENTER OF THE THROUGH LANE.

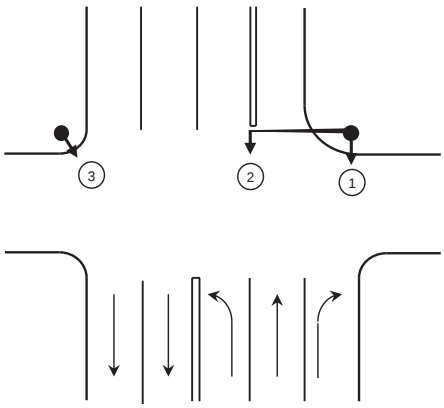
OVERHEAD SIGNAL FACE NO. 3 SHOULD BE LOCATED OVER THE CENTER OF THE LEFT TURN LANE.

SIGNAL FACE INDICATIONS

1. R-Y-G
2. R-Y-G
3. RLA-YLA-GLA
4. RLA-YLA-GLA

Figure 34

PROTECTED/PERMISSIVE LEFT TURN
THREE LANES OF APPROACH (EXCLUSIVE RIGHT)
LOW SPEEDS



NOTE:
OVERHEAD SIGNAL FACE NO. 2 SHOULD BE LOCATED OVER THE LANE LINE.

SIGNAL FACE INDICATIONS

1. R-Y-G
2. R-Y-G-YLA-GLA
3. R-Y-G-YLA-GLA

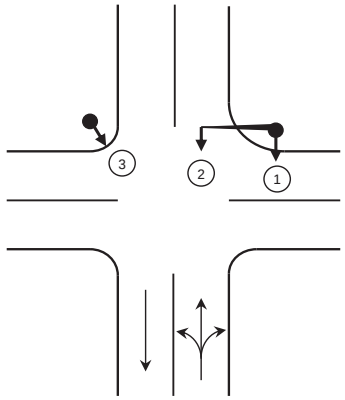
* ensure that opposing left turn heads do not block each other

3.4 HIGH SPEED (NON-FLASHING YELLOW ARROW) CHARTS

Note: The preferred charts are found in Section 3.1 and 3.2. These are maintained for legacy purposes.

Figure 35

SINGLE LANE OF APPROACH
HIGH SPEEDS

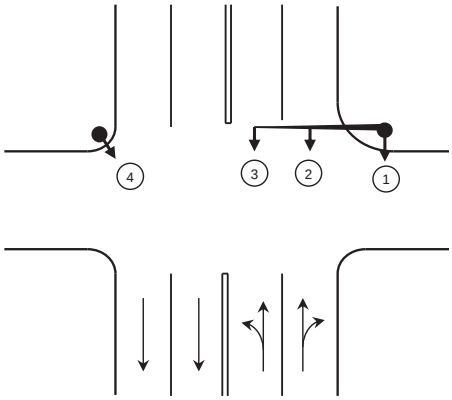


NOTE:
OVERHEAD SIGNAL FACE NO. 2 SHOULD BE LOCATED OVER THE CENTER OF THE THROUGH LANE.

SIGNAL FACE INDICATIONS	
1	R-Y-G
2	R-Y-G
3	R-Y-G

Figure 36

TWO LANES OF APPROACH
HIGH SPEEDS

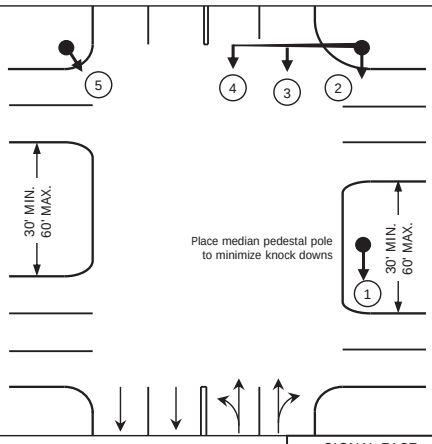


NOTE:
OVERHEAD SIGNAL FACE NO. 2 AND NO. 3 SHOULD BE LOCATED OVER THE CENTER OF THE APPROACH LANES.

SIGNAL FACE INDICATIONS	
1	R-Y-G
2	R-Y-G
3	R-Y-G
4	R-Y-G

Figure 37

TWO LANES OF APPROACH (DIVIDED HIGHWAY)
HIGH SPEEDS



NOTE:
OVERHEAD SIGNAL FACES SHOULD BE LOCATED OVER THE CENTER OF THE APPROACH LANES.

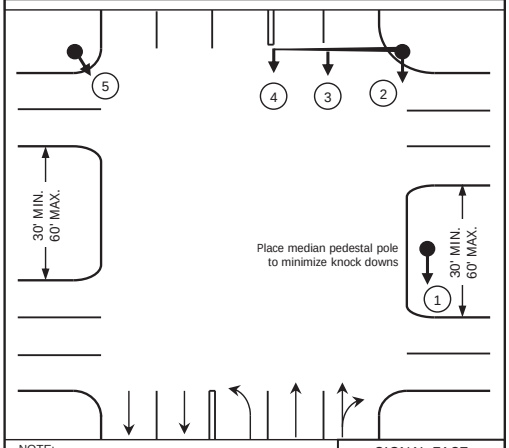
SIGNAL FACE NO. 1 SHOULD BE A PEDESTAL MOUNTED SIGNAL INDICATION

SIGNAL FACE NO. 2 IS OPTIONAL

SIGNAL FACE INDICATIONS	
1	R-Y-G
2	R-Y-G
3	R-Y-G
4	R-Y-G
5	R-Y-G

Figure 38

PROTECTED/PERMISSIVE LEFT TURN
THREE LANES OF APPROACH (DIVIDED HIGHWAY)



NOTE:
OVERHEAD SIGNAL FACES SHOULD BE LOCATED OVER THE LANE LINES.

SIGNAL FACE NO. 1 SHOULD BE A PEDESTAL MOUNTED SIGNAL INDICATION

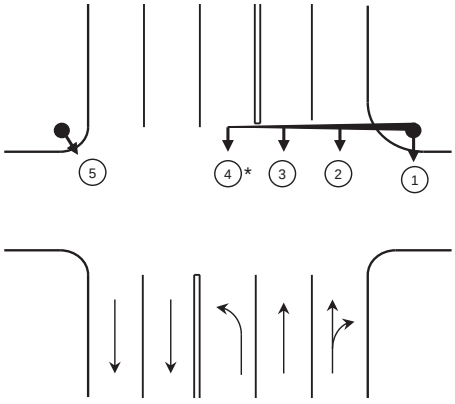
SIGNAL FACE NO. 2 IS OPTIONAL

OVERHEAD SIGNAL FACE NO. 4 SHOULD BE LOCATED OVER THE LANE LINE (NOT CENTERED OVER LEFT LANE)

SIGNAL FACE INDICATIONS	
1	R-Y-G
2	R-Y-G
3	R-Y-G
4	R-Y-G-YLA-GLA
5	R-Y-G-YLA-GLA

Figure 39

PROTECTED LEFT TURN
THREE LANES OF APPROACH
HIGH SPEEDS



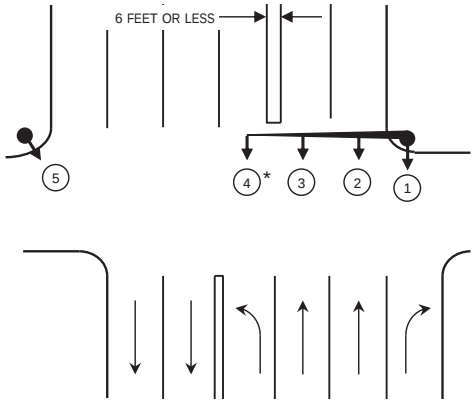
NOTE:
OVERHEAD SIGNAL FACES SHOULD BE LOCATED OVER THE CENTERS OF THE APPROACH LANES.

SIGNAL FACE INDICATIONS

1	R-Y-G
2	R-Y-G
3	R-Y-G
4	RLA-YLA-GLA
5	RLA-YLA-GLA

Figure 40

PROTECTED LEFT TURN
FOUR LANES OF APPROACH
HIGH SPEEDS



NOTE:
OVERHEAD SIGNAL FACES SHALL BE LOCATED OVER THE CENTERS OF THE APPROACH LANES.

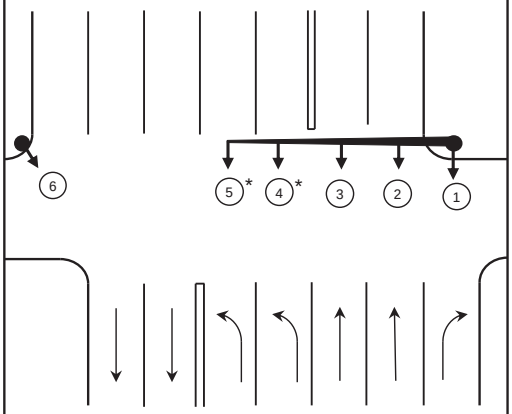
IF THREE OR MORE THRU LANES, ANOTHER SIGNAL FACE SHOULD BE PLACED OVER THE GIVEN LANE.

SIGNAL FACE INDICATIONS

1	R-Y-G
2	R-Y-G
3	R-Y-G
4	RLA-YLA-GLA
5	RLA-YLA-GLA

Figure 41

PROTECTED LEFT TURN
FIVE LANES OF APPROACH (DUAL LEFT TURNS)
HIGH SPEEDS



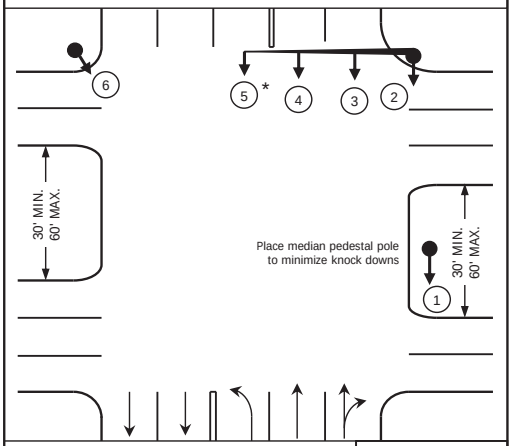
NOTE:
OVERHEAD SIGNAL FACES SHOULD BE LOCATED OVER THE CENTER OF THE APPROACH LANES.

SIGNAL FACE INDICATIONS

1	R-Y-G
3	R-Y-G
2	R-Y-G
4	RLA-YLA-GLA
5	RLA-YLA-GLA
6	RLA-YLA-GLA

Figure 42

PROTECTED LEFT TURN
THREE LANES OF APPROACH (DIVIDED HIGHWAY)



NOTE:
OVERHEAD SIGNAL FACE NO.'S 3 AND 4 SHOULD BE LOCATED OVER THE CENTERS OF THE APPROACH LANES.

OVERHEAD SIGNAL FACE NO. 5 SHOULD BE LOCATED OVER THE CENTER OF THE LEFT TURN LANE.

SIGNAL FACE NO. 1 SHOULD BE A PEDESTAL MOUNTED SIGNAL INDICATION.

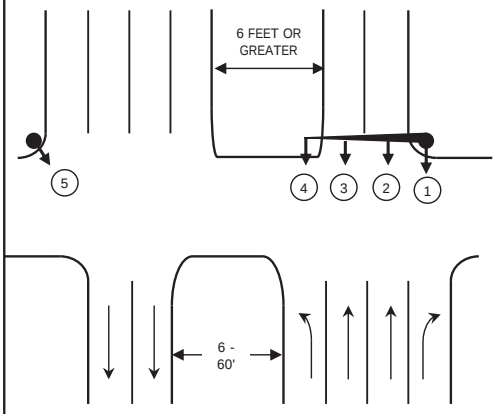
SIGNAL FACE

1	R-Y-G
2	R-Y-G
3	R-Y-G
4	R-Y-G
5	RLA-YLA-GLA
6	RLA-YLA-GLA

* ensure that opposing left turn heads do not block each other

Figure 43

PROTECTED LEFT TURN
FOUR LANES OF APPROACH (WIDE MEDIAN)
HIGH SPEEDS



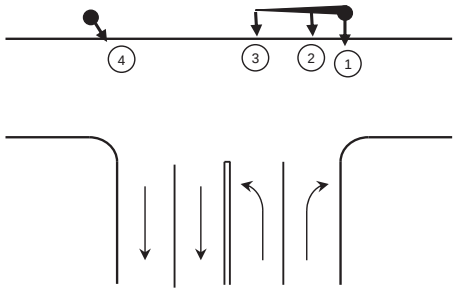
NOTE:
OVERHEAD SIGNAL FACES SHOULD BE LOCATED OVER THE CENTERS OF THE APPROACH LANES.

A PEDESTAL MOUNTED SIGNAL INDICATION MAY BE USED INPLACE OF OVERHEAD SIGNAL FACE NO. 4.

SIGNAL FACE INDICATIONS	
1	R-Y-G
2	R-Y-G
3	R-Y-G
4	RLA-YLA-GLA
5	RLA-YLA-GLA

Figure 44

T-INTERSECTIONS
HIGH SPEEDS



NOTE:
OVERHEAD SIGNAL FACES SHOULD BE LOCATED OVER THE CENTERS OF THE APPROACH LANES.

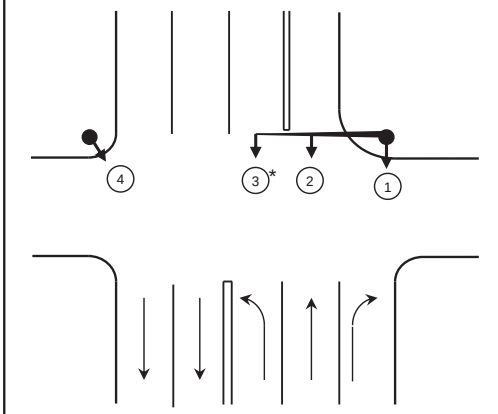
NO PEDS PRESENT:		PEDS CROSS RIGHT SIDE:	
1	RLA-YLA-GLA	1	R-Y-G
2	RLA-YLA-GLA	2	R-Y-G
3	RLA-YLA-GLA	3	RLA-YLA-GLA
4	RLA-YLA-GLA	4	RLA-YLA-GLA

SIGNAL FACE INDICATIONS	
1	R-Y-G
2	R-Y-G
3	R-Y-G
4	R-Y-G

PEDS PRESENT

Figure 45

PROTECTED LEFT TURN
THREE LANES OF APPROACH (EXCLUSIVE RIGHT)
HIGH SPEEDS



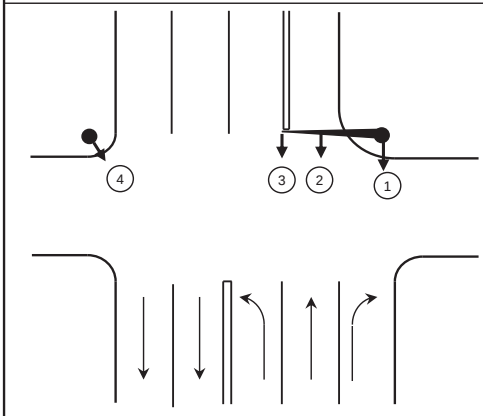
NOTE:
OVERHEAD SIGNAL FACE NO. 2 SHOULD BE LOCATED OVER THE CENTER OF THE THROUGH LANE.

OVERHEAD SIGNAL FACE NO. 3 SHOULD BE LOCATED OVER THE CENTER OF THE LEFT TURN LANE.

SIGNAL FACE INDICATIONS	
1	R-Y-G
2	R-Y-G
3	RLA-YLA-GLA
4	RLA-YLA-GLA

Figure 46

PROTECTED/PERMISSIVE LEFT TURN
THREE LANES OF APPROACH (EXCLUSIVE RIGHT)
HIGH SPEED



NOTE:
OVERHEAD SIGNAL FACES NO. 3 SHOULD BE LOCATED OVER THE LANE LINE.

SIGNAL FACE NO. 2 SHOULD BE AT LEAST 8 FEET AWAY FROM SIGNAL FACE NO. 3.

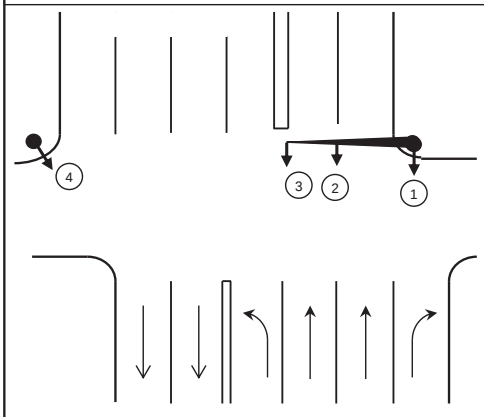
PROTECTED/PERMISSIVE LEFT TURN AT HIGH SPEED SHOULD MEET GUIDELINES.

SIGNAL FACE INDICATIONS	
1	R-Y-G
2	R-Y-G
3	R-Y-G-YLA-GLA
4	R-Y-G-YLA-GLA

* ensure that opposing left turn heads do not block each other

Figure 47

PROTECTED/PERMISSIVE LEFT TURN
FOUR LANES OF APPROACH
HIGH SPEED



NOTE:
OVERHEAD SIGNAL FACE 2 SHALL BE LOCATED OVER THE CENTERS OF THE THRU APPROACH LANES.

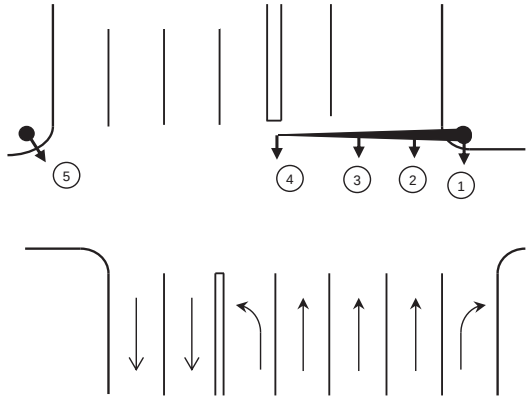
OVERHEAD SIGNAL FACE 3 SHOULD BE LOCATED OVER THE LANE LINE (NOT CENTERED OVER LEFT LANE).

PROTECTED/PERMISSIVE LEFT TURN AT HIGH SPEED SHOULD MEET GUIDELINES.

SIGNAL FACE	
1	R-Y-G
2	R-Y-G
3	R-Y-G-YLA-GLA
4	R-Y-G-YLA-GLA

Figure 48

PROTECTED/PERMISSIVE LEFT TURN
FIVE LANES OF APPROACH
HIGH SPEED



NOTE:
OVERHEAD SIGNAL FACES 2 & 3 SHALL BE LOCATED OVER THE CENTERS OF THE THRU APPROACH LANES.

OVERHEAD SIGNAL FACE 4 SHOULD BE LOCATED OVER LANE LINE (NOT CENTERED OVER LEFT LANE).

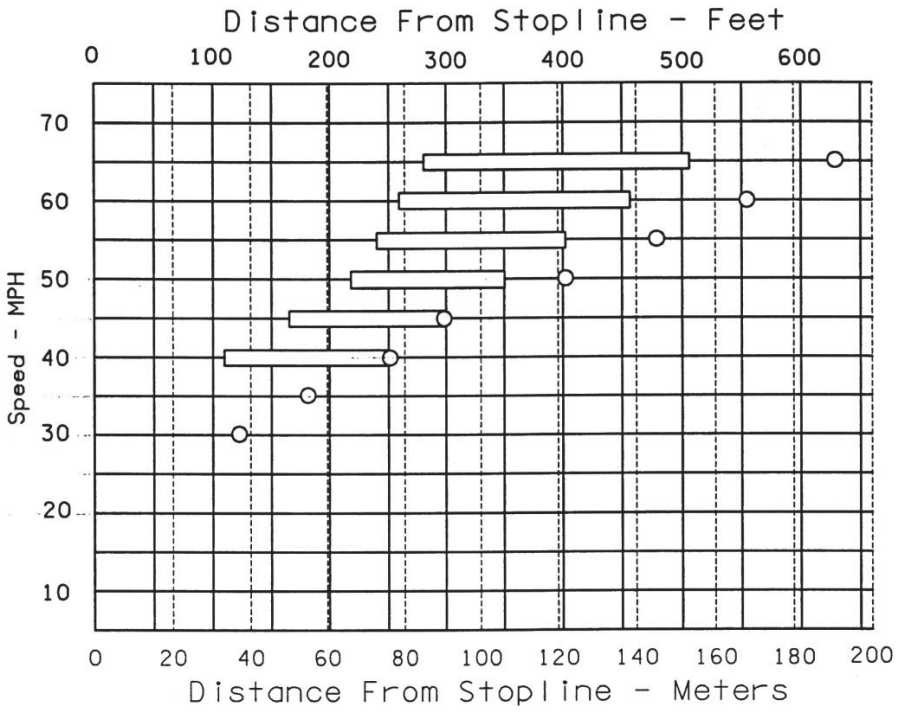
PROTECTED/PERMISSIVE LEFT TURN AT HIGH SPEED SHOULD MEET GUIDELINES.

SIGNAL FACE	
1	R-Y-G
2	R-Y-G
3	R-Y-G
4	R-Y-G-YLA-GLA
5	R-Y-G-YLA-GLA

* ensure that opposing left turn heads do not block each other

Exhibit 4-1 Detector Placement Chart – Decision Zones

DETECTOR PLACEMENT CHART
DECISION ZONES



○ DETECTOR PLACEMENT
□ DECISION ZONE

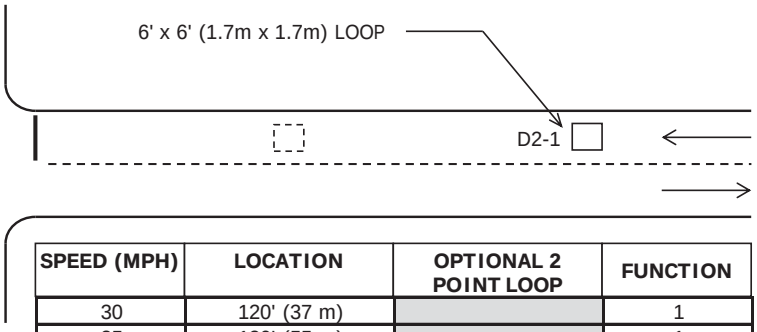
NOTE: Grades and other factors may require adjustment from normal placement.

Detector spacing outside the limits shown may require additional detectors.

Exhibit 4-2 Major Approach

LOOP DETECTOR PLACEMENT

MAJOR APPROACH



SPEED (MPH)	LOCATION	OPTIONAL 2 POINT LOOP	FUNCTION
30	120' (37 m)		1
35	180' (55 m)		1
40	250' (76 m)		1
45	300' (92 m)		1
50	400' (122 m)		1
55	475' (145 m)	240' (75 m)	1
60*	550' (168 m)	275' (84 m)	1
65*	625' (191 m)	315' (96 m)	1

LOCATION = DISTANCE FROM STOP BAR TO LOOP DETECTOR

* ONLY APPLY TO DIVIDED 4-LANE ROADWAY

LOOP DETECTOR FUNCTIONS

1 = CALL AND EXTEND

NOTES:

1) THE LOOP DETECTOR FUNCTION IS CALL AND EXTEND.

2) ONE LOOP FOR EACH APPROACH LANE. AN EFFORT TO EXTEND TURN LANES BEYOND DETECTOR LOCATIONS WILL ENHANCE OPERATIONS EFFICIENCY.

3) IF USING MID-POINT DETECTORS, ENSURE THE LEFT AND RIGHT TURN POCKETS BEGIN BEFORE THE MID-POINT DETECTOR.

4) CONTROLLER PHASE SHALL BE ON VEHICLE RECALL.

5) CONTROLLER PHASE DENSITY FUNCTION (ADDED INITIAL GREEN) SHALL BE USED.

6) OPTIONAL 2 POINT SPACING MAY BE USED FOR 2 LANE ROADWAY WITH SPEED LIMITS OF 45 MPH OR GREATER. SEE CHART FOR LOCATION OF ADDITIONAL LOOP DETECTOR.

7) OPTIONAL STOP LINE DETECTION MAY BE CONSIDERED FOR SHORTENED MINIMUM GREEN TIME.

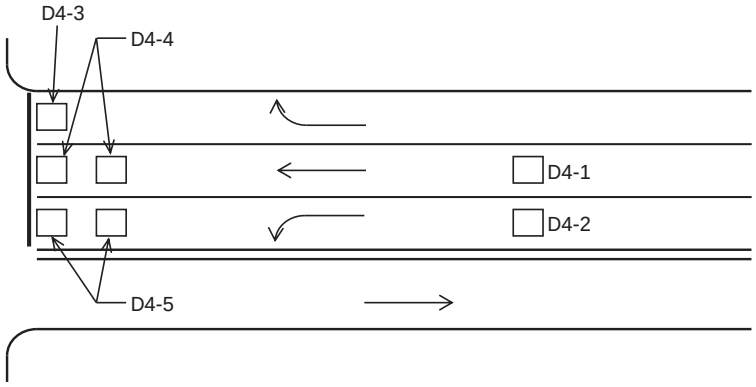
FIGURE 1

Exhibit 4-3 Minor Approach with Right Turn Lane (RTOR Allowed)

LOOP DETECTOR PLACEMENT

MINOR APPROACH

WITH RIGHT TURN LANE (RTOR ALLOWED)



LOCATION = DISTANCE FROM STOP BAR TO LOOP DETECTOR

SPEED (MPH)	LOCATION
30	120' (37 m)
35	180' (55 m)
40	250' (76 m)

LOOP DETECTOR FUNCTIONS
1 = CALL AND EXTEND
7 = DELAY CALL - IMMEDIATE EXTEND

NUMBER	FUNCTION	SIZE
D4-1	1	6' x 6' (1.7 x 1.7 m)
D4-2	1	6' x 6' (1.7 x 1.7 m)
D4-3	7	6' x 6' (1.7 x 1.7 m)
D4-4	1	2-6' x 6' (1.7 x 1.7 m)
D4-5	1	2-6' x 6' (1.7 x 1.7 m)

NOTES:

1) CONTROLLER PHASE CAN OPERATE IN NON-LOCKING MODE.

2) DETECTOR D4-3 COULD BE LARGER (6' X 10', 6' X 12', ETC.) TO ACCOUNT FOR LARGER RIGHT RADIUS.

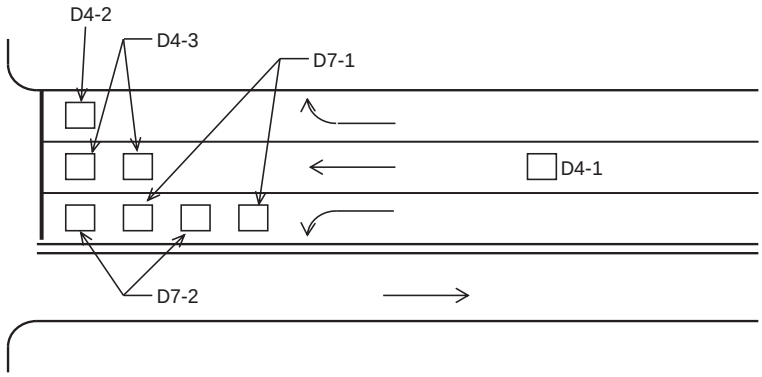
FIGURE 2

Exhibit 4-4 Minor Approach Protected / Permissive Left - 1 Through Lane and Right Turn Lane (RTOR Allowed)

LOOP DETECTOR PLACEMENT

MINOR APPROACH PROTECTED/PERMISSIVE LEFT

1 THROUGH LANE & RIGHT TURN LANE (RTOR ALLOWED)



LOCATION = DISTANCE FROM STOP BAR TO LOOP DETECTOR

LOOP DETECTOR FUNCTIONS
1 = CALL AND EXTEND
7 = DELAY CALL - IMMEDIATE EXTEND

SPEED (MPH)	D4-1 LOCATION
30	120' (37 m)
35	180' (55 m)
40	250' (76 m)

NUMBER	FUNCTION	SIZE	LOCATION
D4-1	1	6' x 6' (1.7 x 1.7 m)	SEE LEFT
D4-2	7	6' x 6' (1.7 x 1.7 m)	5' (1.5 m)
D4-3	1	6' x 6' (1.7 x 1.7 m)	5' & 20' (1.5 & 6 m)
D7-1	1	2-6' x 6' (1.7 x 1.7 m)	20' (6 m) & 50' (15 m)
D7-2	1	2-6' x 6' (1.7 x 1.7 m)	5' (1.5 m) & 35' (11 m)

NOTES:

1) CONTROLLER PHASE CAN OPERATE IN NON-LOCKING MODE.
2) THE LEFT TURN LOOPS WILL CROSS SWITCH WITH THE THROUGH PHASE.
3) SEE FIGURE 5 FOR ADDITIONAL NOTES ON PROTECTED/PERMISSIVE OPERATION.
4) DETECTOR D4-2 COULD BE LARGER (6' X 10', 6' X 12', ETC.) TO ACCOUNT FOR LARGER RIGHT RADIUS.

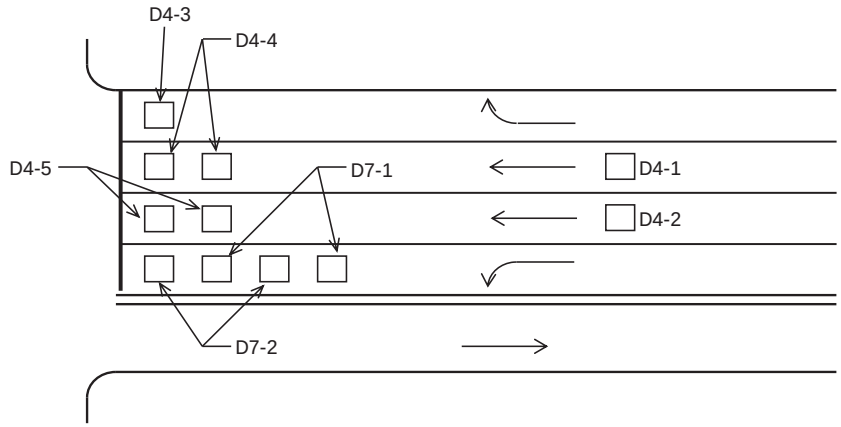
FIGURE 3

Exhibit 4-5 Minor Approach Protected / Permissive Left - 2 Through Lanes and Right Turn Lane (RTOR Allowed)

LOOP DETECTOR PLACEMENT

MINOR APPROACH PROTECTED/PERMISSIVE LEFT

2 THROUGH LANES & RIGHT TURN LANE (RTOR ALLOWED)



LOCATION = DISTANCE FROM STOP BAR TO LOOP DETECTOR

LOOP DETECTOR FUNCTIONS
1 = CALL AND EXTEND
7 = DELAY CALL - IMMEDIATE EXTEND

SPEED (MPH)	D4-1 LOCATION
30	120' (37 m)
35	180' (55 m)
40	250' (76 m)

NUMBER	FUNCTION	SIZE	LOCATION
D4-1	1	6' x 6' (1.7 x 1.7 m)	SEE LEFT
D4-2	1	6' x 6' (1.7 x 1.7 m)	SEE LEFT
D4-3	7	6' x 6' (1.7 x 1.7 m)	5' (1.5 m)
D4-4	1	2-6' x 6' (1.7 x 1.7 m)	5' & 20' (1.5 & 6 m)
D4-5	1	2-6' x 6' (1.7 x 1.7 m)	5' & 20' (1.5 & 6 m)
D7-1	1	2-6' x 6' (1.7 x 1.7 m)	20' (6 m) & 50' (15 m)
D7-2	1	2-6' x 6' (1.7 x 1.7 m)	5' (1.5 m) & 35' (11 m)

NOTES:

1) CONTROLLER PHASE CAN OPERATE IN NON-LOCKING MODE.
2) THE LEFT TURN LOOPS WILL CROSS SWITCH WITH THE THROUGH PHASE.
3) SEE FIGURE 5 FOR ADDITIONAL NOTES ON PROTECTED/PERMISSIVE OPERATION.
4) DETECTOR D4-3 COULD BE LARGER (6' X 10', 6' X 12', ETC.) TO ACCOUNT FOR LARGER RIGHT RADIUS.

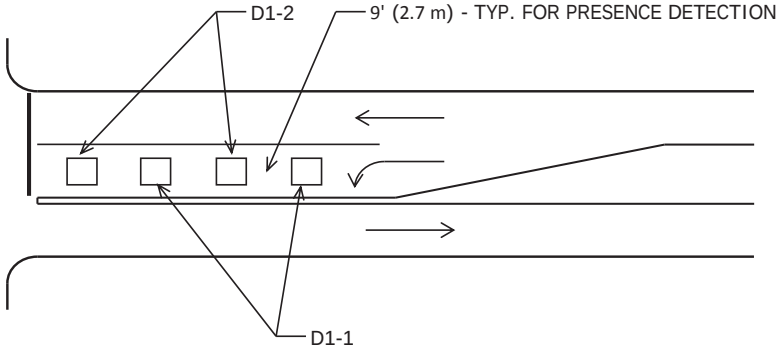
FIGURE 4

Exhibit 4-6 Protected Permissive and FYA Left Turn – Separate Left Turn Lane

LOOP DETECTOR PLACEMENT

PROTECTED/PERMISSIVE AND FLASHING YELLOW LEFT TURN

SEPARATE LEFT TURN LANE



LOOP DETECTOR FUNCTIONS
1 = CALL AND EXTEND

NUMBER	FUNCTION	SIZE	LOCATION
D4-1	1	2-6' x 6' (1.7 x 1.7 m)	20' (6 m) & 50' (15 m)
D4-2	7	2-6' x 6' (1.7 x 1.7 m)	5' (1.5 m) & 35' (11 m)

LOCATION = DISTANCE FROM STOP BAR TO LOOP DETECTOR

NOTES:

1) CONTROLLER PHASE AND DETECTOR FUNCTION SHALL BE NON-LOCK MEMORY WITH NO RECALL.
2) USE BACK UP PROTECTION TO PREVENT LEFT TURN TRAP IF THERE ARE OPPOSING LEFT TURNS.
3) DESIGN SPEED IS 25 MPH.
4) EACH NUMBERED LOOP DETECTOR SHALL HAVE A SEPARATE LEAD-IN CABLE AND SEPARATE AMPLIFIER.
5) IF USING NMC LOOPS, A SINGLE LARGER LOOP CAN REPLACE THE DUALS.
6) DETECTOR CROSS SWITCHING MAY BE USED.
7) USE THIS FIGURE IF INSTALLING A FLASHING YELLOW ARROW (FYA).

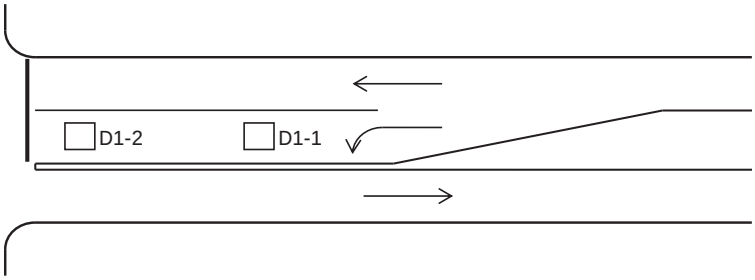
FIGURE 5

Exhibit 4-7 Protected Left Turn - Lock Operation – Raised Median

LOOP DETECTOR PLACEMENT

PROTECTED ONLY LEFT TURN

LOCK OPERATION - RAISED MEDIAN



LOCATION = DISTANCE FROM STOP BAR TO LOOP DETECTOR

FRONT LOOP	BACK LOOP
10' (3 m)	40' (12 m)

LOOP DETECTOR FUNCTIONS
1 = CALL AND EXTEND

NUMBER	FUNCTION	SIZE
D1-1	1	6' x 6' (1.7 x 1.7 m)
D1-2	1	6' x 6' (1.7 x 1.7 m)

NOTES:

1) NO DENSITY FUNCTIONS ARE USED.
2) THE DESIGN SPEED IS 25 MPH.
3) EACH NUMBERED LOOP DETECTOR SHALL HAVE SEPARATE LEAD-IN CABLE AND SEPARATE AMPLIFIER.
4) LOCKING MEMORY SHALL BE USED BY PHASE OR DETECTION FUNCTION. NO CONTROLLER RECALL.
5) THIS CONFIGURATION MAY BE CONSIDERED FOR A FYA OPERATION RETRO-FIT PROJECT.

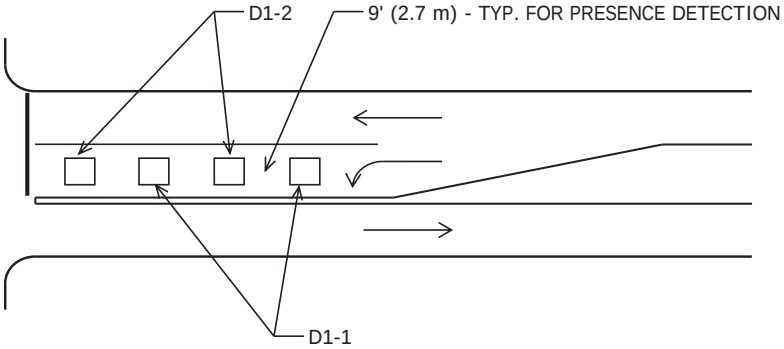
FIGURE 6

Exhibit 4-8 Protected Left Turn - Non Lock Operation – Painted and Non-Raised Median

LOOP DETECTOR PLACEMENT

PROTECTED LEFT TURN

NON LOCK OPERATION - PAINTED & NON-RAISED MEDIAN



LOOP DETECTOR FUNCTIONS
1 = CALL AND EXTEND

NUMBER	FUNCTION	SIZE	LOCATION
D1-1	1	6' x 6' (1.7 x 1.7 m)	20' (6 m) & 50' (15 m)
D1-2	1	6' x 6' (1.7 x 1.7 m)	5' (1.5 m) & 35' (11 m)

LOCATION = DISTANCE FROM STOP BAR TO LOOP DETECTOR

NOTES:

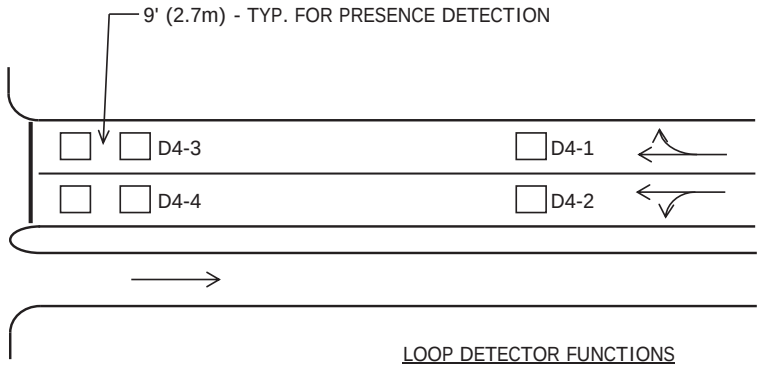
1) **USE IN LOCATIONS WHERE VEHICLES PUT IN FALSE CALLS DUE TO CROSSING OVER DOUBLE YELLOW LINES.**
2) NO DENSITY FUNCTIONS ARE USED.
3) THE DESIGN SPEED IS 25 MPH.
4) EACH NUMBERED LOOP DETECTOR SHALL HAVE SEPARATE LEAD-IN CABLE AND SEPARATE AMPLIFIER.
5) IF LOOPS ARE USED FOR COUNTING, ONE LOOP ON D1-1, THREE LOOPS ON D1-2
6) IF USING NMC, MAY COMBINE DUALS AS LARGER LOOPS.
7) THE CONTROLLER PHASE AND DETECTION FUNCTIONS SHALL BE ON NON-LOCK WITH NO RECALL.

FIGURE 7

Exhibit 4-9 Minor Approach

LOOP DETECTOR PLACEMENT

MINOR APPROACH



LOOP DETECTOR FUNCTIONS
1 = CALL AND EXTEND
3 = EXTEND ONLY
7 = DELAY CALL - IMMEDIATE EXTEND
8 = STOP BAR
9 = STOP BAR WITH DELAY CALL

LOCATION = DISTANCE FROM STOP BAR TO LOOP DETECTOR

SPEED	FRONT LOOP	BACK LOOP
30	5' (1.5m) & 20' (6m)	120' (37 m)
35	5' (1.5m) & 20' (6m)	180' (55 m)
40	5' (1.5m) & 20' (6m)	250' (76 m)
45	5' (1.5m) & 20' (6m)	300' (92 m)
50	5' (1.5m) & 20' (6m)	400' (122 m)
55	5' (1.5m) & 20' (6m)	475' (145 m)

NUMBER	FUNCTION	SIZE
D4-1	3	6' x 6' (1.7 x 1.7 m)
D4-2	1	6' x 6' (1.7 x 1.7 m)
D4-3	7 OR 9	2-6' x 6' (1.7 x 1.7 m)
D4-4	1 OR 8	2-6' x 6' (1.7 x 1.7 m)

NOTES:

1) THE ADDED INITIAL DENSITY FUNCTION IS NOT NECESSARY BECAUSE OF FRONT DETECTORS. THE GAP REDUCTION DENSITY FUNCTION MAY BE CONSIDERED.

2) CONTROLLER PHASE AND DETECTOR FUNCTION SHALL BE NON-LOCK MEMORY WITH NO RECALL.

3) PROVIDE GOOD COVERAGE FOR FRONT DETECTION FOR VARIABLE STOPPING LOCATIONS. USE ANY COMBINATION OF 6' x 6' (1.7m x 1.7m) OR 6' x 10' (1.7m x 3m) LOOP DETECTORS.

4) IF USING NMC LOOP, MAY COMBINE DUAL LOOPS.

5) ADVANCED DETECTION IS OPTIONAL.

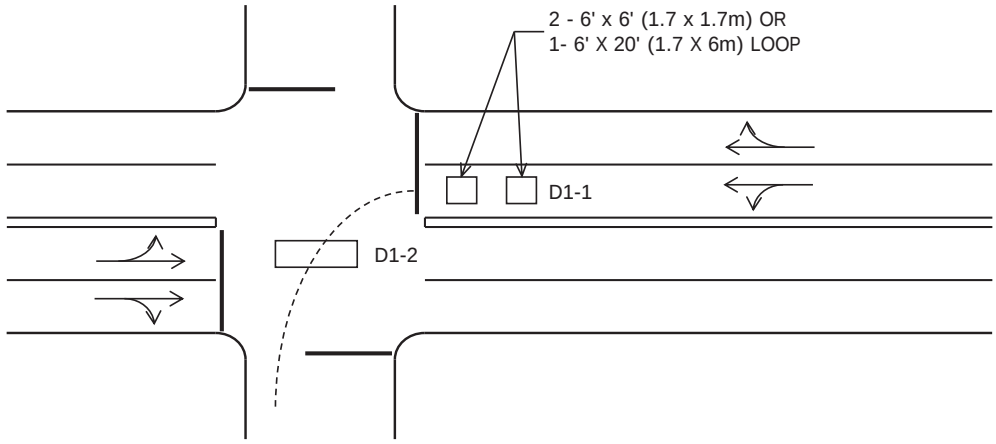
6) USED WITH PRESENCE DETECTION.

FIGURE 8

Exhibit 4-10 Leading Protected / Permissive Left Turn from a Through Lane

LOOP DETECTOR PLACEMENT

LEADING PROTECTED/PERMISSIVE LEFT TURN FROM A THROUGH LANE



LOOP DETECTOR LOCATION:
D1-1 IS LOCATED 1.5m (5') FROM STOP BAR.

D1-2 IS LOCATED OPPOSING THROUGH LANE, CENTERED IN THE TURNING RADIUS OF LEFT TURNING VEHICLES.

LOOP DETECTOR FUNCTIONS
3 = EXTEND ONLY
5 = DELAY CALL ONLY

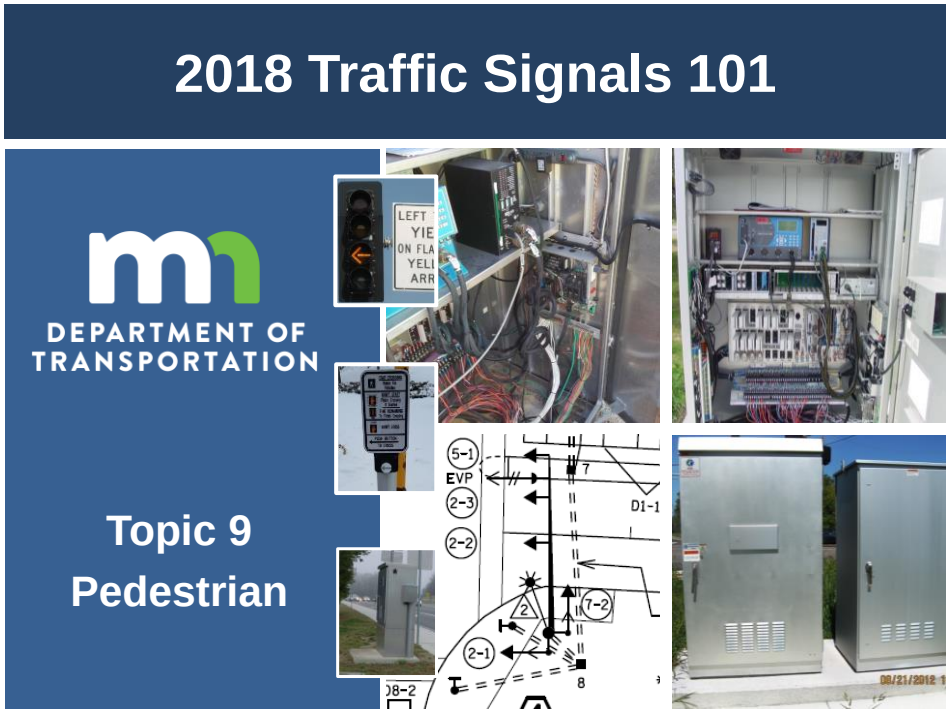
NUMBER	FUNCTION	SIZE
D1-1	5	2-6' x 6' (1.7 x 1.7 m)
D1-2	3	6' x 6' (1.7 x 1.7 m)

NOTES:

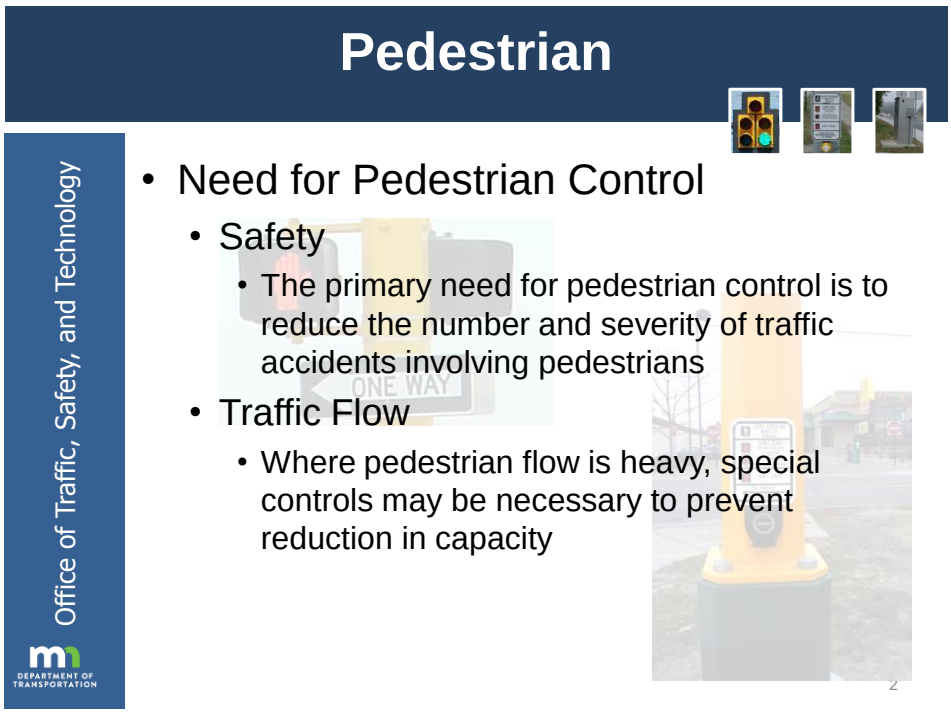
1) LOOP D1-1 SHALL HAVE A 1 - 2 SECOND DELAY, 2 SECOND STRETCH (EXT.), AND IS ONLY ACTIVE DURING PHASE RED.
2) LOOP D1-2 WILL ONLY EXTEND IT'S OWN PHASE (GREEN ARROW).
3) USE BACK UP PROTECTION TO PREVENT LEFT TURN TRAP IF THERE ARE OPPOSING LEFT TURNS.
4) CONTROLLER PHASE DENSITY FUNCTIONS SHALL NOT BE USED.
5) CONTROLLER PHASE AND DETECTOR FUNCTION SHALL BE ON NON-LOCK MEMORY.
6) THE DESIGN SPEED IS 20 MPH.
7) IF NO OPPOSING LEFT TURN, NOTE 3 IS NOT NECESSARY.

FIGURE 9

TOPIC 9: PEDESTRIAN



In this topic you will be introduced to the movement of pedestrians at signalized intersections.



Safety. Pedestrians are slow and fragile as compared to motor vehicles; a collision between a vehicle and a pedestrian almost always results in at least an injury, often a fatality. The pedestrian population includes many people who are not familiar with traffic laws (one does not need to pass an examination to become a pedestrian).

Traffic Flow. At unsignalized intersections a steady stream of pedestrians preempting crosswalks may reduce vehicular capacity considerably. At signalized intersections lacking special pedestrian signals, conflicts between vehicular movements and pedestrians may cause congestion.

Pedestrian

Office of Traffic, Safety, and Technology

- Pedestrian Timing Requirements
  - The pedestrian timing requirements include:
    - The Walk Interval
    - Flashing Don't Walk Interval (Pedestrian Clearance)

3

Pedestrian timing includes the Walk time (defined on slide 4 below) and the Flashing Don't Walk time (defined on slide 5 on the next page).

Pedestrian

Office of Traffic, Safety, and Technology

- Pedestrian Timing Requirements
  - Walk: The walk interval is typically 4 to 7 seconds. This allows pedestrians adequate time to leave the curb and begin crossing
  - MnDOT typically uses 7 seconds, based on MN MUTCD Guidance
  - Under special circumstances, such as at a school crossing with numerous pedestrians, walk times may need to exceed 7 seconds

4

The Walk interval is the time given to allow the pedestrian to leave the curb and begin crossing the street.

Mn/DOT typically uses 7 seconds.

The MN MUTCD, Chapter 4E guidance is to use 7 seconds. The MN MUTCD indicates this option:

"If pedestrian volumes and characteristics do not require a 7-second walk interval, walk intervals as short as 4 seconds may be used."

Pedestrian

Office of Traffic, Safety, and Technology

- Pedestrian Timing Requirements
  - Flashing Don't Walk (FDW) or pedestrian clearance is the time provided for a pedestrian crossing in a crosswalk, after leaving the curb or shoulder, to travel to the far side of the traveled way or to a median (D = Distance)
  - The calculation of the flashing don't walk (pedestrian clearance) is:

    FDW = D / R
  - R = Walking Rate, 3.5 feet per second according to MN MUTCD

5

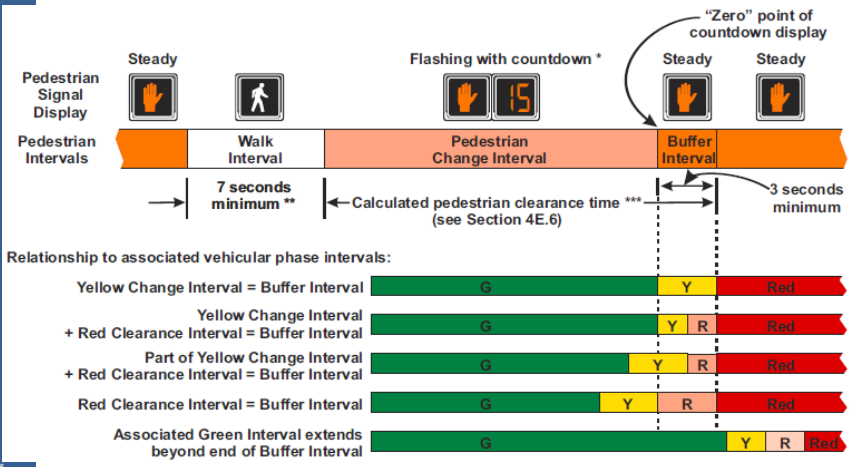
The Flashing Don't Walk is calculated as the amount of time required to cross the street. This should allow pedestrians adequate time to cross the roadway safely. It is based on the Distance to cross (D) and the rate at which a pedestrian walks (R).

The MN MUTCD specifies a walking rate of 3.5 feet per second. There is an option to use a walking rate of 4.0 feet per second IF there is an extended push button feature or passive pedestrian detection.

Pedestrian

Office of Traffic, Safety, and Technology

- MN MUTCD Figure 4E-2



6

The Figure illustrates the pedestrian intervals and their possible relationships with associated vehicular signal phase intervals.

Pedestrian

Office of Traffic, Safety, and Technology

- Ped Timing Recommended Practice
  - For a single roadway or a divided roadway with a median island less than 6 feet wide, the pedestrian is provided time to cross the entire intersection, without stopping in the middle
    - WALK = 7 seconds (this may be reduced to 4 seconds if it is necessary to minimize pedestrian timing considering the other factors)

7

More details on Mn/DOT's recommended timing practice can be found in the Traffic Signal Timing and Coordination Manual.

Pedestrian

Office of Traffic, Safety, and Technology

- Ped Timing Recommended Practice
  - FDW = (D/R)
  - (time should not be less than WALK time and the time may be reduced by the yellow interval IF it is necessary to minimize pedestrian timing considering other factors)

8

D is the distance across, from curb to the far side of the farthest travel lane.

R is the walking rate in feet per second. Guidance is to use 3.5 feet/second, but 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.

Pedestrian

Office of Traffic, Safety, and Technology

- Divided Roadways (with Median)
  - Option 1 - Cross to Median Only
    - (for divided roadways with median islands over 6 feet wide with pedestrian indications and button in the median)
  - Option 2 - Cross Completely

9

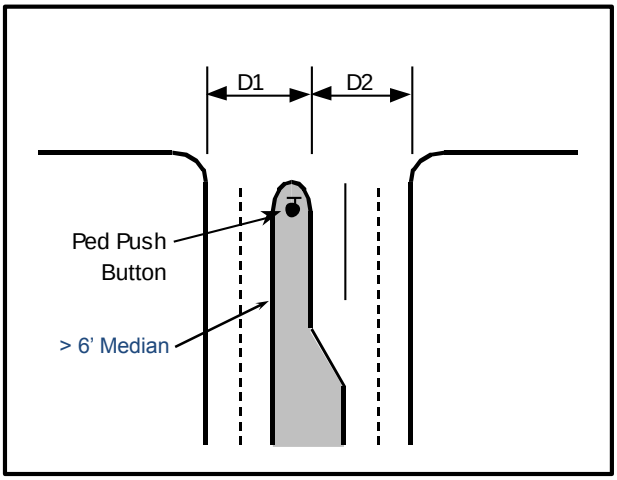
For Option 1, the crossing distance should be determined by using the longest distance from one side to the median.

For Option 2, the timing is sufficient to allow a pedestrian who starts to cross on the beginning of Walk, to cross the entire roadway. A pedestrian, who begins to cross later, may have to stop in the median, press the ped button, and wait for the next Walk.

- Walk = D1/R
- Flashing DON'T Walk = (D2/R)

Pedestrian

Office of Traffic, Safety, and Technology



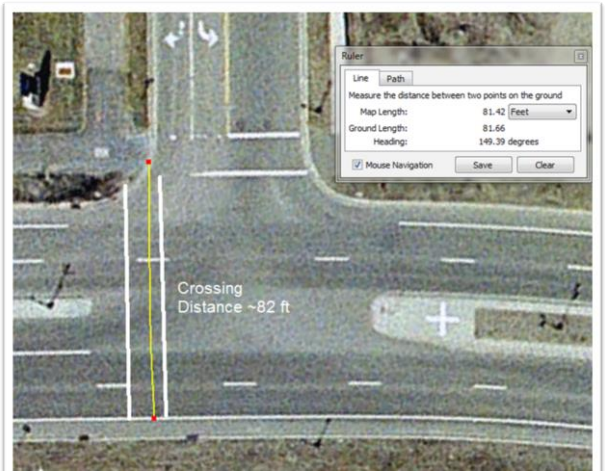
10

This graphic shows the measurements of D1 and D2.

Pedestrian

Office of Traffic, Safety, and Technology

- Pedestrian Timing Requirements Example



11

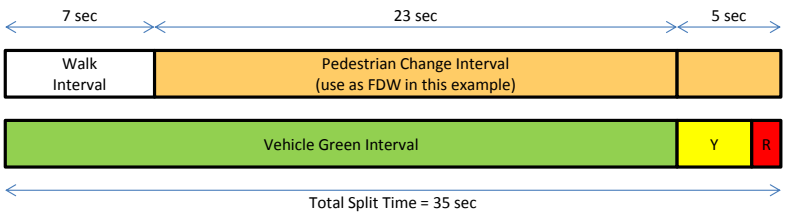
Pedestrian timing requirement example. For this example a pedestrian is required to cross in the north-south direction (82 feet). In this example, the distance D is used as 82 feet.

Pedestrian

Excel

Office of Traffic, Safety, and Technology

- Pedestrian Timing Requirements Example
  - Assume a walking speed of 3.5 feet per second with no special pedestrian requirements
  - The flashing don't walk would then be:
    - FDW = 82 feet / 3.5 feet per second = 23 seconds
  - Total Split Time (given vehicle yellow = 4 seconds and all-red = 1 second) is 35 seconds



In this example the pedestrian would typically be given a 7 second Walk proceeding the Don't Walk.

For normal conditions, 3.5 feet per seconds is used as the crossing speed. This speed may need to be reduced under special circumstances.

For this example, the pedestrian clearance time will be set to equal the controller FDW. The "buffer" or solid don't walk is equal to the Yellow and All-Red for the vehicle phase.

Total time needed for the concurrent vehicle phase is 35 seconds.

Pedestrian

Office of Traffic, Safety, and Technology

WAIT HERE

PUSH BUTTON FOR WALK SIGNAL

in medians

PUSH BUTTON FOR WALK SIGNAL

CROSS TO CENTER

at corners

13

Pedestrian Information Sign

- To provide pedestrians with more information at the traffic signal
- The pedestrian informational sign shall be used on all traffic signal installations that have pedestrian indications.

Handout

Excerpts from MN MUTCD (Page 4E-1 to 4E-11)

For the latest version of the MN MUTCD, please visit:

www.dot.state.mn.us/trafficeng/publ/mutcd/index.html

PART 4. HIGHWAY TRAFFIC SIGNALS

Chapter 4E. Pedestrian Control Features

4E.1 Pedestrian Signal Heads

SUPPORT:

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

GUIDANCE:

Except when required by this manual, engineering judgment should determine the need for separate pedestrian signal heads (see Section 4D.3) and accessible pedestrian signals (see Section 4E.6).

SUPPORT:

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

4E.2 Meaning of Pedestrian Signal Head Indications

STANDARD:

Pedestrian signal head indications shall have the following meanings:

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

B. A flashing UPRAISED HAND (symbolizing DONT WALK) signal indication means that a pedestrian shall not start to cross the roadway in the direction of the signal indication, but that any pedestrian who has already started to cross on a steady WALKING PERSON (symbolizing WALK) signal indication shall 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.

C. A steady UPRAISED HAND (symbolizing DONT WALK) signal indication means that a pedestrian shall not enter the roadway in the direction of the signal indication.

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

4E.3 Application of Pedestrian Signal Heads

STANDARD:

Pedestrian signal heads shall be used in conjunction with vehicular traffic control signals under any of the following conditions:

A. If a traffic control signal is justified by an engineering study and meets either Warrant 4, Pedestrian Volume or Warrant 5, School Crossing (see Chapter 4C);

B. If an exclusive signal phase is provided or made available for pedestrian movements in one or more directions, with all conflicting vehicular movements being stopped;

C. At an established school crossing at any signalized location; or

D. Where engineering judgment determines that multi-phase signal indications (as with split-phase timing) would tend to confuse or cause conflicts with pedestrians using a crosswalk guided only by vehicular signal indications.

GUIDANCE:

Pedestrian signal heads should be used under any of the following conditions:

A. If it is necessary to assist pedestrians in deciding when to begin crossing the roadway in the chosen direction or if engineering judgment determines that pedestrian signal heads are justified to minimize vehicle-pedestrian conflicts;

B. If pedestrians are permitted to cross a portion of a street, such as to or from a median of sufficient width for pedestrians to wait, during a particular interval but are not permitted to cross the remainder of the street during any part of the same interval; and/or

C. If no vehicular signal indications are visible to pedestrians, or if the vehicular signal indications that are visible to pedestrians starting a crossing provide insufficient guidance for them to decide when to begin crossing the roadway in the chosen direction, such as on one-way streets, at T-intersections, or at multi-phase signal operations.

4E.4 Size, Design, and Illumination of Pedestrian Signal Head Indications

STANDARD:

All new pedestrian signal head indications shall be displayed within a rectangular background and shall consist of symbolized messages (see Figure 4E-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 Federal "Standard Highway Signs and Markings" book (see Section 1A.11) shall be used. Each pedestrian signal head indication shall be independently displayed and emit a single color.

If a two-section pedestrian signal had 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.

The WALKING PERSON (symbolizing WALK) signal indication shall be white, conforming to the publication entitled "Pedestrian Traffic Control Signal Indications" (see Section 1A.11), with all except the symbol obscured by an opaque material.

The UPRAISED HAND (symbolizing DONT WALK) signal indication shall be Portland orange, conforming to the publication entitled "Pedestrian Traffic Control Signal Indications" (see Section 1A.11), with all except the symbol obscured by an opaque material.

When not illuminated, the WALKING PERSON (symbolizing WALK) and UPRAISED HAND (symbolizing DONT WALK) symbols shall not be readily visible to pedestrians at the far end of the crosswalk that the pedestrian signal head indications control.

For pedestrian signal head indications, the symbols shall be at least 150 mm (6 in) high.

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 nor more than 60 times per minute. The displayed period of each flash shall be a minimum of ½ and a maximum of 2/3 of the total flash cycle.

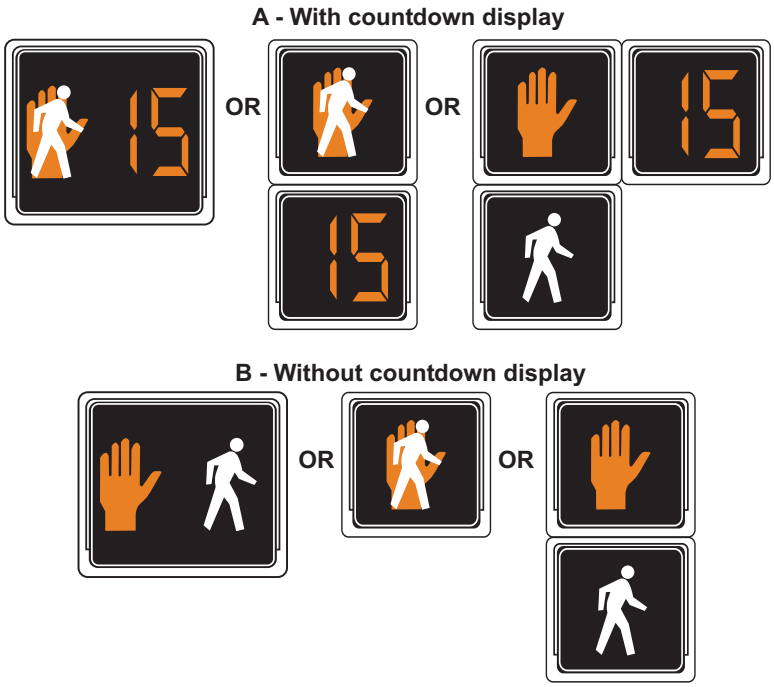


Figure 4E-1. Typical Pedestrian Signal Indications

GUIDANCE:

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.

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.

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.

4E.5 Location and Height of Pedestrian Signal Heads

STANDARD:

Pedestrian signal heads shall be mounted with the bottom of the signal housing including brackets not less than 7 feet nor more than 10 feet above sidewalk level, and shall be positioned and adjusted to provide maximum visibility at the beginning of the controlled crosswalk.

If pedestrian signal heads are mounted on the same support as vehicular signal heads, there shall be a physical separation between them.

4E.6 Pedestrian Intervals and Signal Phases

STANDARD:

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.

When the pedestrian signal heads associated with a crosswalk are displaying either a steady WALKING PERSON (symbolizing WALK) or a flashing UPRAISED HAND (symbolizing DON'T WALK) signal indication, a steady or a flashing red signal indication shall be shown to any conflicting vehicular movement that is approaching the intersection or mid-block location perpendicular or nearly perpendicular to the crosswalk.

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.

MN Rev. 1

A pedestrian change interval consisting of a flashing UPRAISED HAND (symbolizing DON'T 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 3 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 the following paragraphs starting with the first Guidance paragraph and ending with the second Standard paragraph). The buffer interval shall not begin later than the beginning of the red clearance interval, if used.

Compliance Date: June 13, 2017

OPTION:

MN Rev. 1

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:

Figure 4E-2 illustrates the pedestrian intervals and their possible relationships with associated vehicular signal phase intervals.

GUIDANCE:

Except as provided above, the pedestrian clearance time should be sufficient to allow a pedestrian crossing in the crosswalk who left the curb or shoulder 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:

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 pushbutton 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.

The additional time provided by an extended pushbutton press to satisfy pedestrian clearance time needs may be added to either the walk interval or the pedestrian change interval.

GUIDANCE:

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.

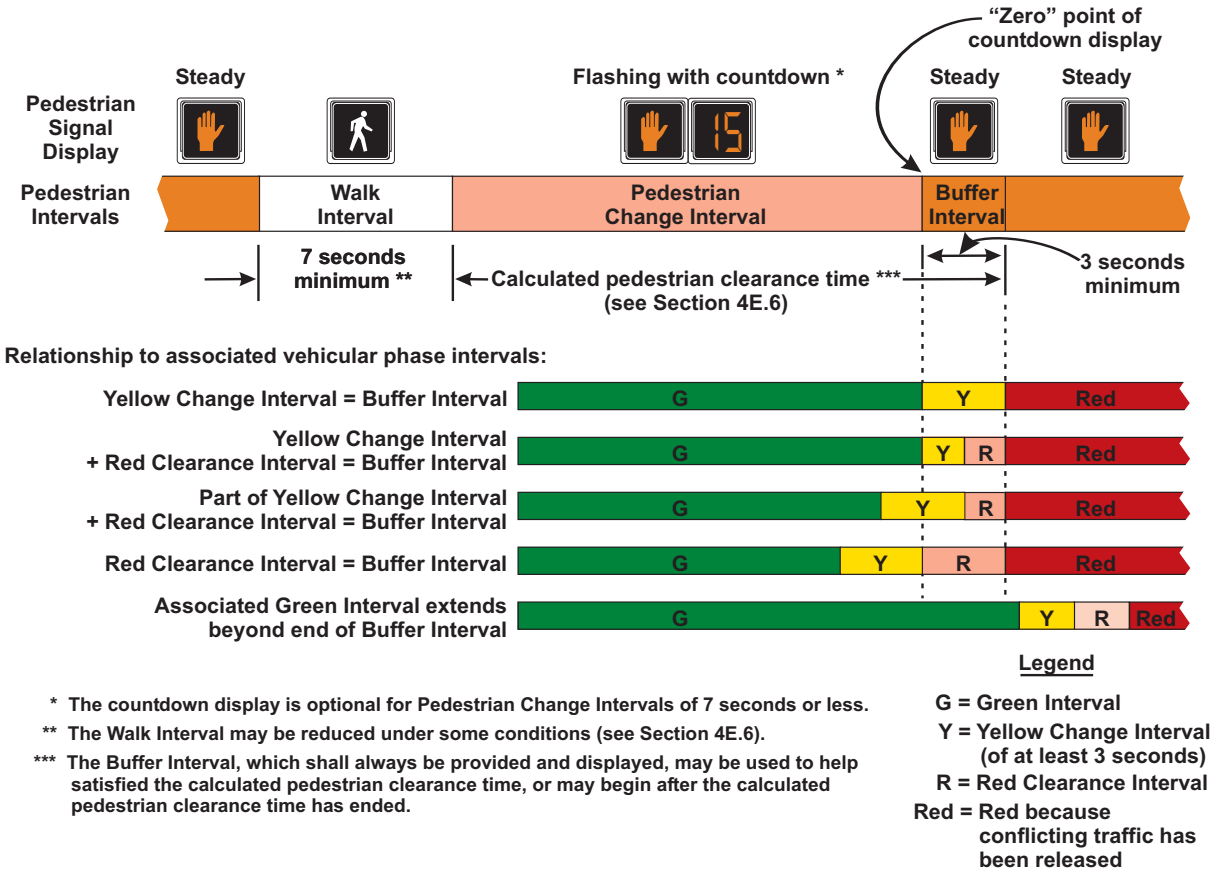


Figure 4E-2. Pedestrian Intervals

Except as provided in below, 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:

If pedestrian volumes and characteristics do not require a 7-second walk interval, walk intervals as short as 4 seconds may be used.

SUPPORT:

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:

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 from the face of the curb or from 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:

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:

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 if actuated operation is used) shall be provided (see Sections 4E.8 and 4E.9) and signing such as the R10-3d sign (see Section 2B.52) shall be provided to notify pedestrians to cross only to the median to await the next WALKING PERSON (symbolizing WALK) signal indication.

GUIDANCE:

Where median-mounted pedestrian signals and detectors are provided, the use of accessible pedestrian signals (see Sections 4E.09 through 4E.13) should be considered.

OPTION:

During the transition into preemption, the walk interval and the pedestrian change interval may be shortened or omitted as described in Section 4D.27.

At intersections with high pedestrian volumes and high conflicting 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.

GUIDANCE:

If a leading pedestrian interval is used, the use of accessible pedestrian signals (see Sections 4E.09 through 4E.13) should be considered.

SUPPORT:

If a leading pedestrian interval is used without accessible features, pedestrians who are visually impaired can be expected to begin crossing at the onset of the vehicular movement when drivers are not expecting them to begin crossing.

GUIDANCE:

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.

If a leading pedestrian interval is used, consideration should be given to prohibiting turns across the crosswalk during the leading pedestrian interval.

SUPPORT:

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.

4E.7 Countdown Pedestrian Signals

STANDARD:

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:

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:

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.

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 4E-1).

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.

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 or during the red clearance interval of a concurrent vehicular phase.

GUIDANCE:

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 4E.6) 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.

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.

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.

If the pedestrian change interval is interrupted or shortened as a part of a transition into a preemption sequence (see Section 4E.6), the countdown pedestrian signal display should be discontinued and go dark immediately upon activation of the preemption transition.

4E.8 Pedestrian Detectors

MN Rev. 1

OPTION:

Pedestrian detectors may be pushbuttons or passive detection devices.

SUPPORT:

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.

The provisions in this Section place pedestrian pushbuttons within easy reach of pedestrians who are intending to cross each crosswalk and make it obvious which pushbutton is associated with each crosswalk. These provisions also position pushbutton poles in optimal locations for installation of accessible pedestrian signals (see Sections 4E.09 through 4E.13). Information regarding reach ranges can be found in the "Americans with Disabilities Act Accessibility Guidelines for Buildings and Facilities (ADAAG)" (see Section 1A.11).

GUIDANCE:

If pedestrian pushbuttons are used, they should be capable of easy activation and conveniently located near each end of the crosswalks. Except as provided in the following 2 paragraphs, pedestrian pushbuttons should be located to meet all of the following criteria:

A. Unobstructed and adjacent to a level all-weather surface to provide access from a wheelchair;
B. Where there is an all-weather surface, a wheelchair accessible route from the pushbutton to the ramp;
C. Between the edge of the crosswalk line (extended) farthest from the center of the intersection and the side of a curb ramp (if present), but not greater than 5 feet from said crosswalk line;
D. Between 1.5 and 6 feet from the edge of the curb, shoulder, or pavement;
E. With the face of the pushbutton parallel to the crosswalk to be used; and
F. At a mounting height of approximately 3.5 feet, but no more than 4 feet, above the sidewalk.

Where there are constraints that make it impractical to place the pedestrian pushbutton adjacent to a level all-weather surface, the surface should be as level as feasible.

Where there are constraints that make it impractical to place the pedestrian pushbutton between 1.5 and 6 feet from the edge of the curb, shoulder, or pavement, it should not be farther than 10 feet from the edge of curb, shoulder, or pavement.

Except as provided in the following Option, where two pedestrian pushbuttons are provided on the same corner of a signalized location, the pushbuttons should be separated by a distance of at least 10 feet.

OPTION:

Where there are constraints on a particular corner that make it impractical to provide the 10-foot separation between the two pedestrian pushbuttons, the pushbuttons may be placed closer together or on the same pole

STANDARD:

Signs (see Section 2B. 52) shall be mounted adjacent to or integral with pedestrian pushbuttons, explaining their purpose and use.

OPTION:

At certain locations, a supplemental sign in a more visible location may be used to call attention to the pedestrian pushbutton.

STANDARD:

The positioning of pedestrian pushbuttons and the legends on the pedestrian pushbutton signs shall clearly

indicate which crosswalk signal is actuated by each pedestrian pushbutton.

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:

The use of additional pedestrian detectors on islands or medians where a pedestrian might become stranded should be considered.

If used, special purpose pushbuttons (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:

If used, a pilot light or other means of indication installed with a pedestrian pushbutton 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.

If a pilot light is used at an accessible pedestrian signal location (see Sections 4E.09 through 4E.13), each actuation shall be accompanied by the speech message "wait."

OPTION:

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 pushbutton press.

STANDARD:

If additional crossing time is provided by means of an extended pushbutton press, a PUSH BUTTON FOR 2 SECONDS FOR EXTRA CROSSING TIME (R10-32P) plaque (see Figure 2B-26) shall be mounted adjacent to or integral with the pedestrian pushbutton.

4E.9 Accessible Pedestrian Signals and Detectors - General

SUPPORT:

Accessible pedestrian signals and detectors provide information in non-visual formats (such as audible tones, speech messages, and/or vibrating surfaces).

The primary technique that pedestrians who have visual 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 who have visual disabilities need to cross a roadway at a signalized location.

GUIDANCE:

If a particular signalized location presents difficulties for pedestrians who have visual disabilities to cross the roadway, an engineering study should be conducted that considers the needs of pedestrians in general, as well as the information needs of pedestrians with visual disabilities. The engineering study, should consider the following factors:

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 traffic signal phasing (such as split phases, protected turn phases, leading pedestrian intervals, and exclusive pedestrian phases); and
E. The complexity of intersection geometry.

SUPPORT:

The factors that make crossing at a signalized location difficult for pedestrians who have visual disabilities include: increasingly quiet cars, right turn on red (which masks the beginning of the through phase), continuous right-turn movements, complex signal operations, traffic circles, and wide streets. Further, low traffic volumes might make it difficult for pedestrians who have visual disabilities to discern signal phase changes.

Local organizations, providing support services to pedestrians who have visual and/or hearing disabilities, can often act as important advisors to the traffic engineer when consideration is being given to the installation of devices to assist such pedestrians. Additionally, orientation and mobility specialists or similar staff also might be able to provide a wide range of advice. The U.S. Access Board's (www.access-board.gov) provides technical assistance for making pedestrian signal information available to persons with visual disabilities (see Page i for the address for the U.S. Access Board).

STANDARD:

When used, accessible pedestrian signals shall be used in combination with pedestrian signal timing. The information provided by an accessible pedestrian signal shall clearly indicate which pedestrian crossing is served by each device.

Under stop-and-go operation, accessible pedestrian signals shall not be limited in operation by the time of day or day of week.

OPTION:

Accessible pedestrian signal detectors may be pushbuttons or passive detection devices.

At locations with pretimed traffic control signals or non-actuated approaches, pedestrian pushbuttons may be used to activate the accessible pedestrian signals.

SUPPORT:

Accessible pedestrian signals are typically integrated into the pedestrian detector (pushbutton), so the audible tones and/or messages come from the pushbutton housing. They have a pushbutton locator tone and tactile arrow, and can include audible beaconing and other special features.

OPTION:

The name of the street to be crossed may also be provided in accessible format, such as Braille or raised print. Tactile maps of crosswalks may also be provided.

SUPPORT:

Specifications regarding the use of Braille or raised print for traffic control devices can be found in the "Americans with Disabilities Act Accessibility Guidelines for Buildings and Facilities (ADAAG)" (see Section 1A.11).

STANDARD:

At accessible pedestrian signal locations where pedestrian pushbuttons are used, each pushbutton shall activate both the walk interval and the accessible pedestrian signals.

4E.10 Accessible Pedestrian Signals and Detectors - Location

SUPPORT:

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:

Pushbuttons for accessible pedestrian signals should be located in accordance with the provisions of Section 4E.8 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:

If two accessible pedestrian pushbuttons are placed less than 10 feet apart or on the same pole, each accessible pedestrian pushbutton shall be provided with the following features (see Sections 4E.11 through 4E.13):

A. A pushbutton locator tone,

B. A tactile arrow,

C. A speech walk message for the WALKING PERSON (symbolizing WALK) indication, and

D. A speech pushbutton information message.

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 accessible pedestrian detectors are used, an additional accessible pedestrian detector shall be provided in the median.

4E.11 Accessible Pedestrian Signals and Detectors - Walk Indications

SUPPORT:

Technology that provides different sounds for each non-concurrent signal phase has frequently been found to provide ambiguous information. Research indicates that a rapid tick tone for each crossing coming from accessible pedestrian signal devices on separated poles located close to each crosswalk provides unambiguous information to pedestrians who are blind or visually impaired. 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:

Accessible pedestrian signals shall have both audible and vibrotactile walk indications.

Vibrotactile walk indications shall be provided by a tactile arrow on the pushbutton (see Section 4E.12) that vibrates during the walk interval.

Accessible pedestrian signals shall have an audible walk indication during the walk interval only. The audible walk indication shall be audible from the beginning of the associate crosswalk.

The accessible walk indication shall have the same duration as the pedestrian walk signal except when the pedestrian signal rests in walk.

GUIDANCE:

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 greater than the pedestrian change interval.

STANDARD:

Where two accessible pedestrian signals are separated by a distance of at least 10 feet, the audible walk indication shall be a percussive tone. Where two accessible pedestrian

signals on one corner are not separated by a distance of at least 10 feet, the audible walk indication shall be a speech walk message.

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:

The volume of audible walk indications and pushbutton locator tones (see Section 4E.12) 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 pushbutton press.

STANDARD:

Automatic volume adjustment in response to ambient traffic sound level shall be provided up to a maximum volume of 100 dBA.

GUIDANCE:

The sound level of audible walk indications and pushbutton locator tones should be adjusted to be low enough to avoid misleading pedestrians who have visual 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:

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:

An alert tone can be particularly useful if the walk tone is not easily audible in some traffic conditions.

Speech walk messages communicate to pedestrians which street has the walk interval. Speech messages might be either directly audible or transmitted, requiring a personal receiver to hear the message. 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.

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 visual 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 pushbutton. This can be done by means of a speech pushbutton information message (see Section 4E.13) during the flashing or steady UPRAISED HAND intervals, or by raised print and Braille labels on the pushbutton housing.

By combining the information from the pushbutton message or Braille label, the tactile arrow aligned in the direction of travel on the relevant crosswalk, and the speech walk message, pedestrians with visual disabilities are able to correctly respond to speech walk messages even if there are two pushbuttons on the same pole.

STANDARD:

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. Speech walk messages shall be used only at intersections where it is technically infeasible to install two accessible pedestrian signals at one corner separated by a distance of at least 10 feet.

Speech walk messages that are used at intersections having pedestrian phasing that is concurrent with vehicular phasing shall be patterned after the model: "Broadway. Walk sign is on to cross Broadway."

Speech walk messages that are used at intersections having exclusive pedestrian phasing shall be patterned after the model: "Walk sign is on for all crossings."

Speech walk messages shall not contain any additional information, except they shall include designations such as "Street" or "Avenue" where this information is necessary to avoid ambiguity at a particular location.

GUIDANCE:

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:

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.

If a pilot light (see Section 4E.8) is used at an accessible pedestrian signal location, each actuation shall be accompanied by the speech message "wait."

OPTION:

Accessible pedestrian signals that provide speech walk messages may provide similar messages in languages other than English, if needed, except for the terms "walk sign" and "wait."

STANDARD:

Following the audible walk indication, accessible pedestrian signals shall revert to the pushbutton locator tone (see Section 4E.12) during the pedestrian change interval.

4E.12 Accessible Pedestrian Signals and Detectors - Tactile Arrows and Locator Tones

STANDARD:

To enable pedestrians who have visual disabilities to distinguish and locate the appropriate pushbutton at an accessible pedestrian signal location, pushbuttons shall clearly indicate by means of tactile arrows which crosswalk signal is actuated by each pushbutton. Tactile arrows shall be located on the pushbutton, 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.

An accessible pedestrian pushbutton shall incorporate locator tone.

SUPPORT:

A pushbutton locator tone is a repeating sound that informs approaching pedestrians that a pushbutton to actuate pedestrian timing or receive additional information exists, and that enables pedestrians with visual disabilities to locate the pushbutton.

STANDARD:

Pushbutton locator tones shall have a duration of 0.15 seconds or less and shall repeat at 1-second intervals.

Pushbutton locator tones shall be deactivated when the traffic control signal 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 stop-and-go mode by pedestrian actuations.

Pushbutton locator tones shall be intensity responsive to ambient sound, and be audible 1.8 to 3.7 m (6 to 12 ft) from the pushbutton, or to the building line, whichever is less.

SUPPORT:

Section 4E.11 contains additional provisions regarding the volume and sound level of pushbutton locator tones.

4E.13 Accessible Pedestrian Signals and Detectors - Extended Pushbutton Press Features

OPTION:

Pedestrians may be provided with additional features such as increased crossing time, audible beaconing, or a speech pushbutton information message as a result of an extended pushbutton press.

STANDARD:

If an extended pushbutton press is used to provide any additional feature(s), a pushbutton press of less than one second shall actuate only the pedestrian timing and any associated accessible walk indication, and a pushbutton press of two seconds or more shall actuate the pedestrian timing, any associated accessible walk indication, and any additional feature(s).

If additional crossing time is provided by means of an extended pushbutton press, a PUSH BUTTON FOR 2 SECONDS FOR EXTRA CROSSING TIME (R10-32P) plaque (see Figure 2B-26) shall be mounted adjacent to or integral with the pedestrian pushbutton.

SUPPORT:

Audible beaconing is the use of an audible signal in such a way that pedestrians with visual disabilities can home in on the signal that is located on the far end of the crosswalk as they cross the street.

Not all crosswalks at an intersection need audible beaconing; audible beaconing can actually cause confusion if used at all crosswalks at some intersections. Audible beaconing is not appropriate at locations with channelized turns or split phasing, because of the possibility of confusion.

GUIDANCE:

Audible beaconing should only be considered following an engineering study at:

A. Crosswalks longer than 70 feet, unless they 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 an individual with visual disabilities; or
E. Other locations where a study indicates audible beaconing would be beneficial.

OPTION:

Audible beaconing may be provided in several ways, any of which are initiated by an extended pushbutton press.

STANDARD:

If audible beaconing is used, the volume of the pushbutton locator tone during the pedestrian change interval of the called pedestrian phase shall be increased and operated in one of the following ways:

A. The louder audible walk indication and louder locator tone comes from the far end of the crosswalk, as pedestrians cross the street,
B. The louder locator tone comes from both ends of the crosswalk, or
C. The louder locator tone comes from an additional speaker that is aimed at the center of the crosswalk and that is mounted on a pedestrian signal head.

OPTION:

Speech pushbutton 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:

If speech pushbutton 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:

Speech pushbutton information messages should not be used to provide landmark information or to inform pedestrians with visual disabilities about detours or temporary traffic control situations.

SUPPORT:

Additional information on the structure and wording of speech pushbutton information messages is included in ITE's "Electronic Toolbox for Making Intersections More Accessible

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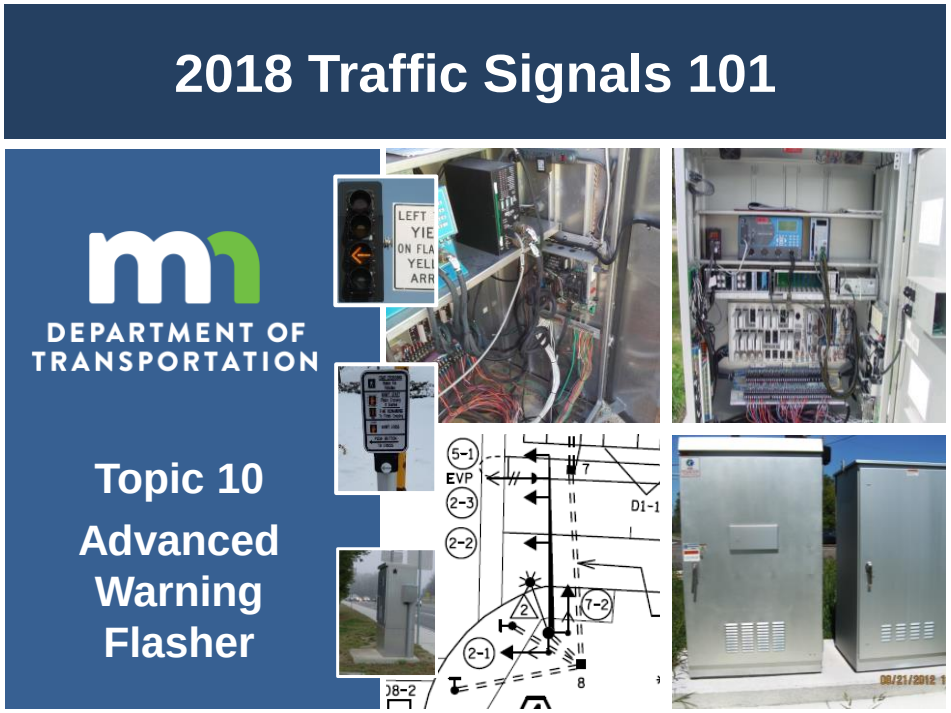
TOPIC 10: ADVANCED WARNING FLASHER



In this topic you will be introduced to Advanced Warning Flashers (AWF).

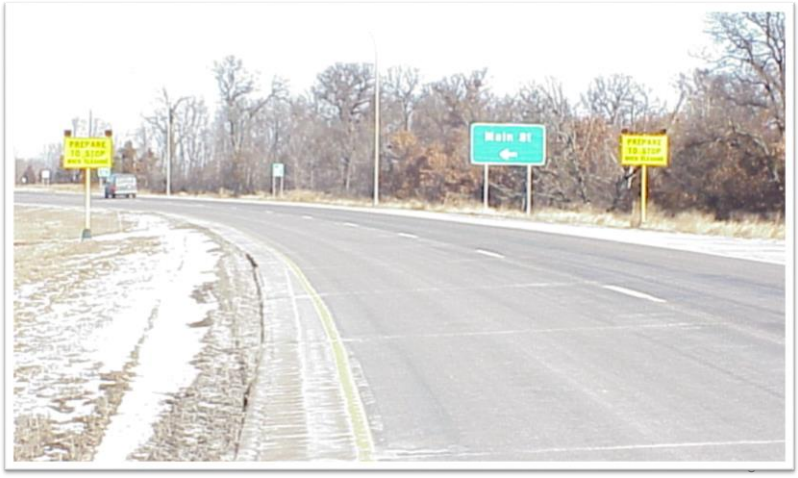
The information presented in this section is from the MN MUTCD Section 4O and the Traffic Signal Timing and Coordination Manual. A copy of the relevant sections from these documents is included at the end of this topic.

Picture of an Advanced Warning Flasher.

Advanced Warning

Office of Traffic, Safety, and Technology

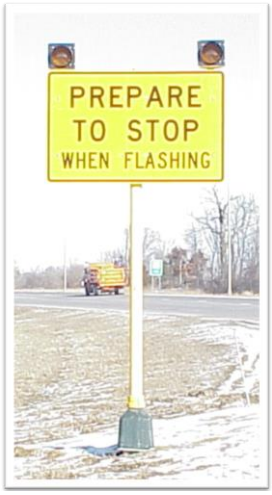
- Advanced Warning Flasher



Advanced Warning

Office of Traffic, Safety, and Technology

- Advanced Warning Flasher



4

Front and rear view of AWF.

Advanced Warning

Office of Traffic, Safety, and Technology

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

5

The purpose of the Advanced Warning Flasher.

Advanced Warning

Office of Traffic, Safety, and Technology

- Advanced Warning Flasher
  - The additional information includes a sign/flasher combination to get the driver's attention and a specific notice that the driver must prepare to stop

6

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

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

Advanced Warning

Office of Traffic, Safety, and Technology

- Advanced Warning Flasher Consideration
  - Isolated or unexpected signalized intersection
  - Limited sight distance
  - Dilemma Zone
  - Accidents
  - Heavy Truck Volume
  - Engineering Judgment

7

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

Advanced Warning

Office of Traffic, Safety, and Technology

- Guidelines for Installation (MUTCD 4O)
  - Advanced Warning Flasher
  - Advanced Warning Flasher Sign Placement
  - Leading Flash
  - Detector Placement

8

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

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

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

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

Advanced Warning

Office of Traffic, Safety, and Technology

- Guidelines for Installation (MUTCD 4O)

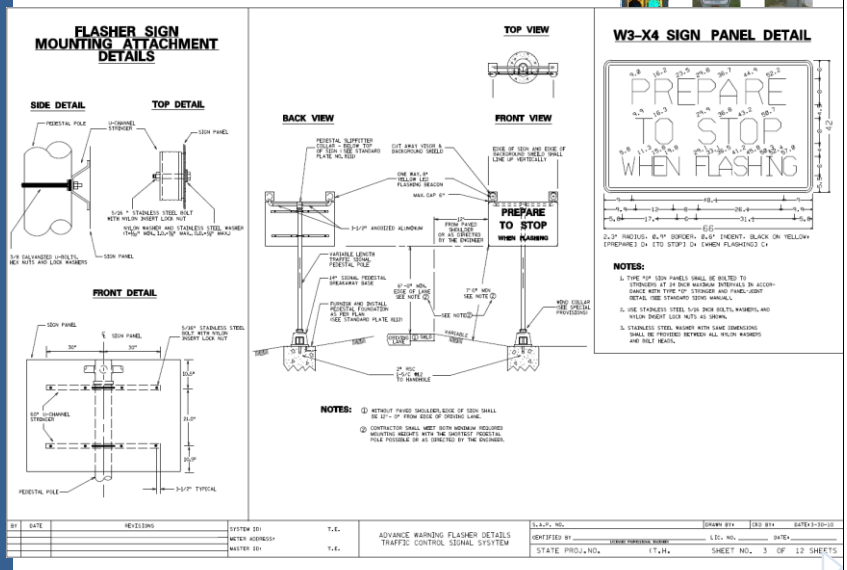
Posted Speeds (mph)	AWF Placement (feet)	Leading Flash (seconds)
40	560	8.0
45	560	7.0
50	700	8.0
55	700	7.0
60	850	8.0
65	850	7.5

9

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

Advanced Warning

Office of Traffic, Safety, and Technology



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

Handout

Excerpts from the Traffic Signal Timing and Coordination Manual, and the Minnesota Manual on Uniform Traffic Control Devices (MN MUTCD), Chapter 4

For the latest version, please visit:

www.dot.state.mn.us/trafficeng/publ/index.html

4.14 Guidelines for Consideration and Timing of Advanced Warning Flashers

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

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

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

CATEGORY	CRITERIA	COMMENT
1. Isolated or Unexpected signalized intersection	Where there is a long distance from the last intersection at which the mainline is controlled, or the intersection is otherwise unexpected.	This guideline may be applicable where the distance from the last intersection is greater than 10 miles, or at a freeway terminus, or at other locations where the intersection is unexpected.
2. Limited sight distance	Where the distance to the stop bar, D, with two signal heads visible is insufficient: $D \leq 1.467vt + \frac{v^2}{0.93(a + 32.2s)}$ Where: D = distance to stop bar feet v = posted speed in mph t = reaction time, 2.5 seconds a = deceleration rate 8 ft/s^2 (trucks) 10 ft/s^2 (all traffic) s = decimal gradient	See Graphs of Limited Sight Distance, Exhibit 4-12 & Exhibit 4-13. A sight distance falling below the lines for the given speed and grade indicates the possible need for AWF.

CATEGORY	CRITERIA	COMMENT
3. Dilemma Zone	Where a dilemma zone exists for all traffic or for heavy vehicles. A dilemma zone exists if: $$Y \le t + \frac{1.467v}{2(a + 32.2s)}$$ Where: Y = yellow interval in seconds v = Posted speed in mph t = 1 second a = deceleration rate 8 ft/s^2 (trucks) 10 ft/s^2 (all traffic) s = decimal gradient	See Graphs on Minimum Yellow Intervals, Exhibit 4-14 & Exhibit 4-15. If the yellow interval is less than indicated, AWF may be considered (longer yellow should be considered first).
4. Crashes	If an approach has an crash problem, the intersection should be examined for existence of dilemma zone or sight distance restriction.	If no sight distance or dilemma zone problems exist, AWF may not be an appropriate countermeasure to crash problems.
5. Heavy Truck Volume	Where the roadway has a grade of 3% or greater and truck volume exceeds 15%.	
6. Engineering Judgment		

Combinations of above guidelines or other considerations may justify the installation of AWF.

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

Guidelines for Installation

1. **Advanced Warning Flasher** - The Advanced Warning Flasher design details are shown on the web: www.dot.state.mn.us/trafficeng/signals/signaldetails.html. The flasher shall flash yellow in a (inside-outside) wig-wag manner prior to the termination of the green (See number 3, below), and during the yellow and red periods of the signal. The flasher will also flash if the signal goes into flashing operation. Power shall be supplied to the AWF from the signal control cabinet.

2. **Advanced Warning Flasher Sign Placement** - The AWF should be set back from the intersection in accordance with the table shown below. At locations on four lane divided roadway, the AWF shall be placed on both sides of the approach.

Posted Speeds (mph)	AWF Placement	Leading Flash (seconds)
40	560 ft	8.0
45	560 ft	7.0
50	700 ft	8.0
55	700 ft	7.0
60	850 ft	8.0
65	850 ft	7.5

3. **Leading Flash** - The Leading Flash is the amount of time, prior to the signal turning yellow, that the AWF flashes. The AWF shall flash during the Leading Flash Period and continue flashing through the signal's yellow clearance interval and the red. The Leading Flash time is shown in the table above.

For existing systems where the placement is other than what is listed in the table above, the Leading Flash Time can be computed by the following formula:

Where:

F = Leading Flash Time, seconds

D = AWF Placement, feet

v = posted speeds, mph

$$F = \frac{0.68D}{v} - 1.5$$

4. **Detector Placement** - The detection of the intersection shall be determined without regard to the AWF.

Exhibit 4-12 AWF Limited Sight Distance (> 15% Trucks)

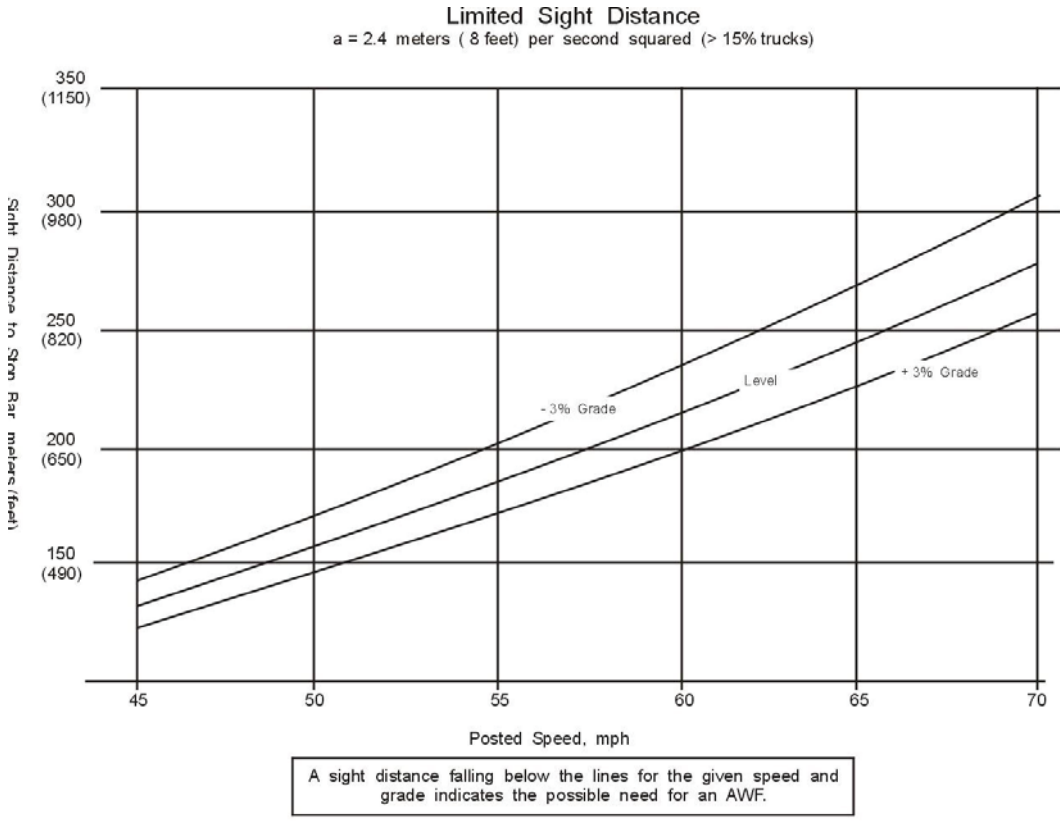
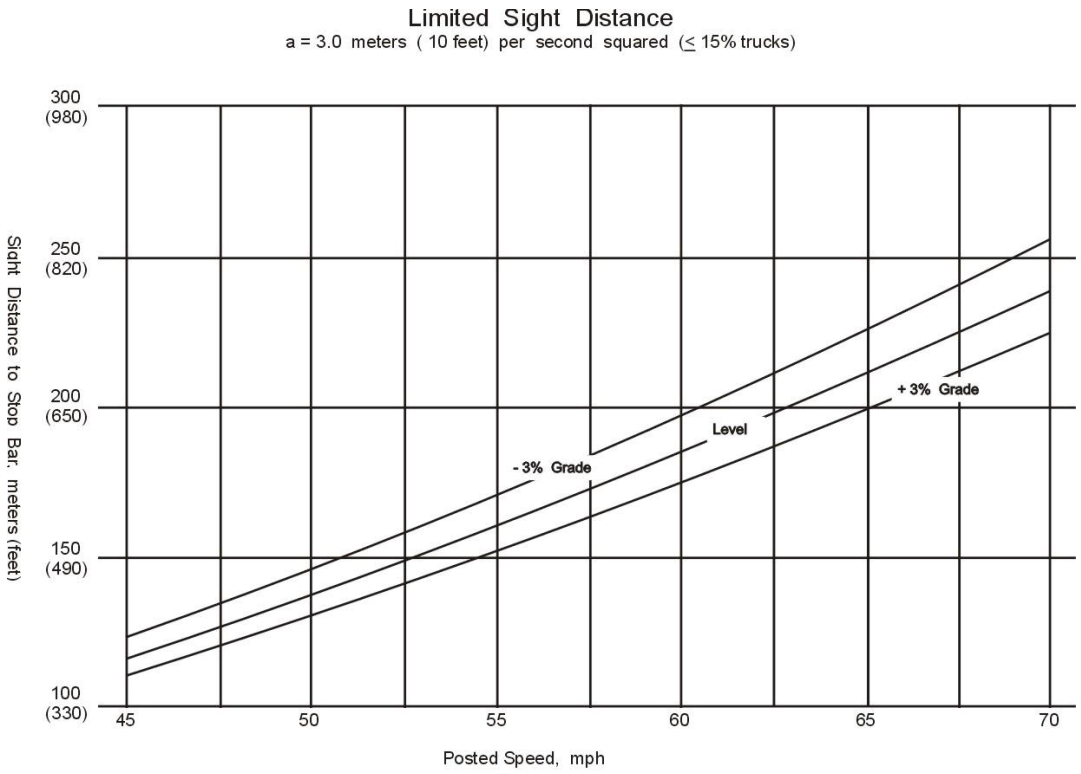


Exhibit 4-13 AWF Limited Sight Distance (≤ 15% Trucks)



A sight distance falling below the lines for the given speed and grade indicates the possible need for an AWF.

Exhibit 4-14 AWF Recommended Yellow Intervals (> 15% Trucks)

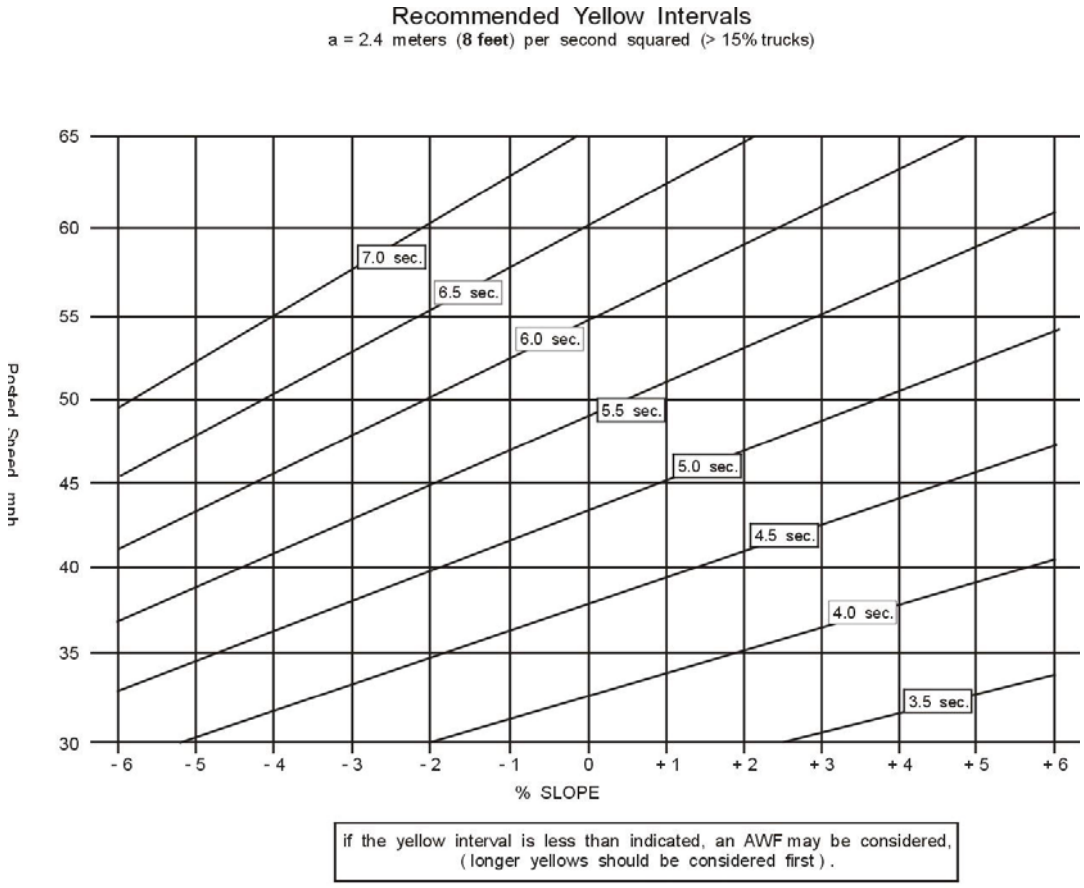
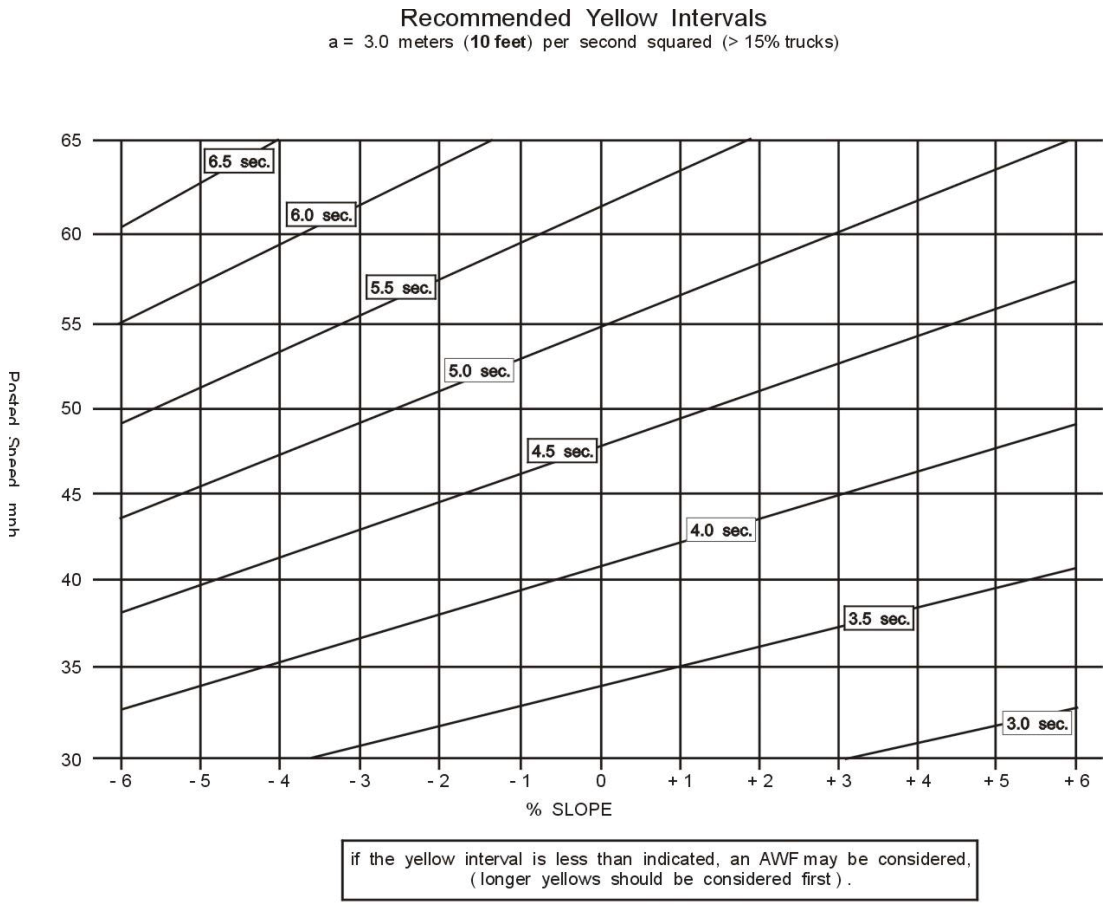


Exhibit 4-15 AWF Recommended Yellow Intervals (≤ 15% Trucks)



See **MN MUTCD** for the Installation and Operation of Advanced Warning Flashers.

PART 4. HIGHWAY TRAFFIC SIGNALS

Chapter 4O. Advance Warning Flashers

4O.1 Description

SUPPORT:

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

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

OPTION:

Advance Warning Flashers may be used at traffic signals.

4O.2 General Design and Operation

STANDARD:

If used, the Advance Warning Flasher assembly shall be as shown in Figure 4O-1. The flasher shall flash yellow in a alternating manner prior to the termination of the green, and during the yellow and red periods of the signal. The flasher shall also flash if the signal goes into flashing mode.

Posted Speeds (mph)	AWF Placement (feet)	Leading Flash (seconds)
40	560	8.0
45	560	7.0
50	700	8.0
55	700	7.0
60	850	8.0
65	850	7.5

Table 4O-1. Advance Warning Sign Placement

GUIDANCE:

If used, then the following should apply:

Advance Warning Flasher - The Advance Warning Flasher power should be supplied from the signal control cabinet.

Advance Warning Flasher Sign Placement - The Advance Warning Flasher should be set back from the intersection in accordance with Table 4O-1. Where this is not possible, the leading flash should be adjusted for the actual distance by using the formula below. At locations on four-lane divided roadways, it should be placed on both sides of the approach.

Leading Flash Period - The Advance Warning Flasher should flash prior to the termination of the green for the Leading Flash Period shown in Table 4O-1. For existing systems where the placement is other than what is listed in Table 4O-1, the Leading Flash Period should be computed by the following formula:

English: $F = \frac{0.68D}{v} - 1.5$

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

Detector Placement - The detection of the intersection should be determined without regard to the Advance Warning Flasher.

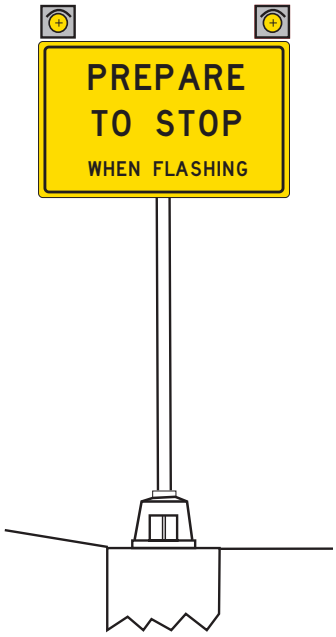


Figure 4O-1. Advance Warning Assembly

HANDOUT

HANDOUT

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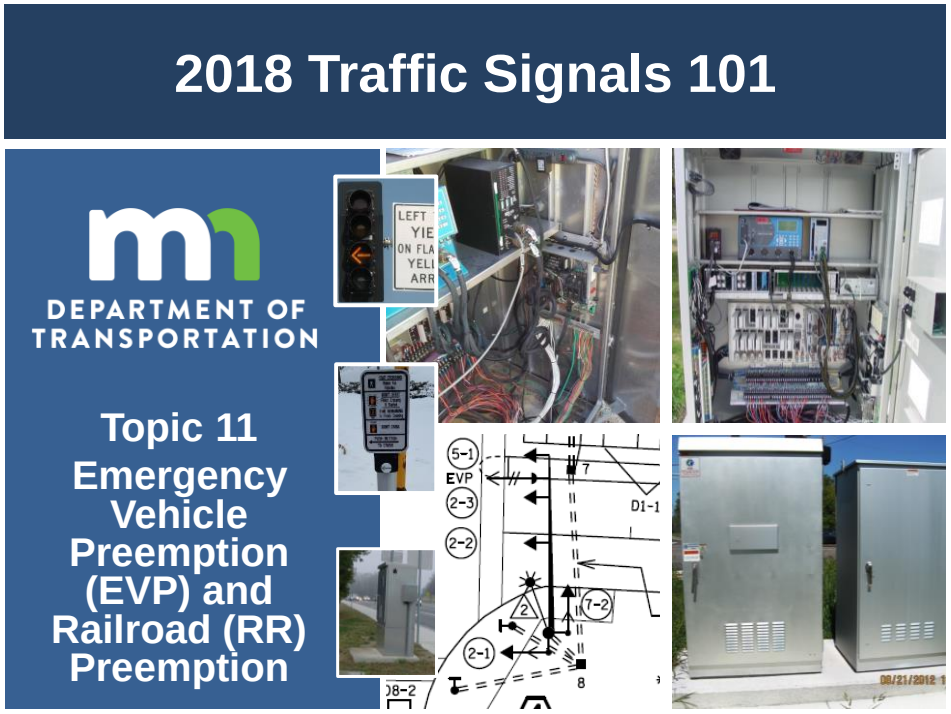
HANDOUT

HANDOUT

TOPIC 11: EMERGENCY VEHICLE PREEMPTION (EVP) AND RAILROAD PREEMPTION

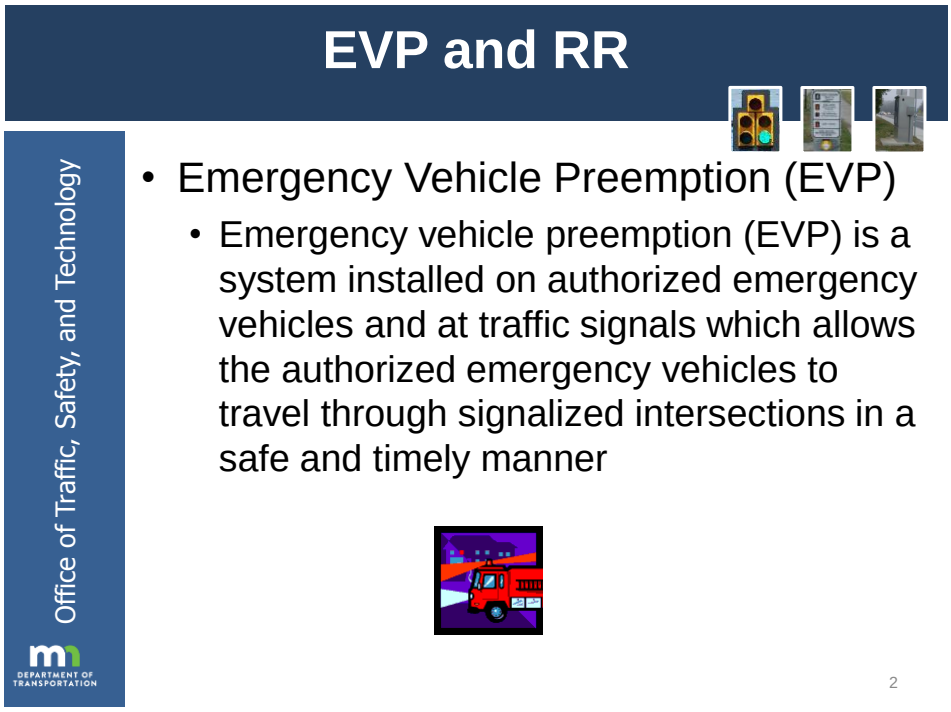


The transfer of signal control to a special signal operation is called preemption.

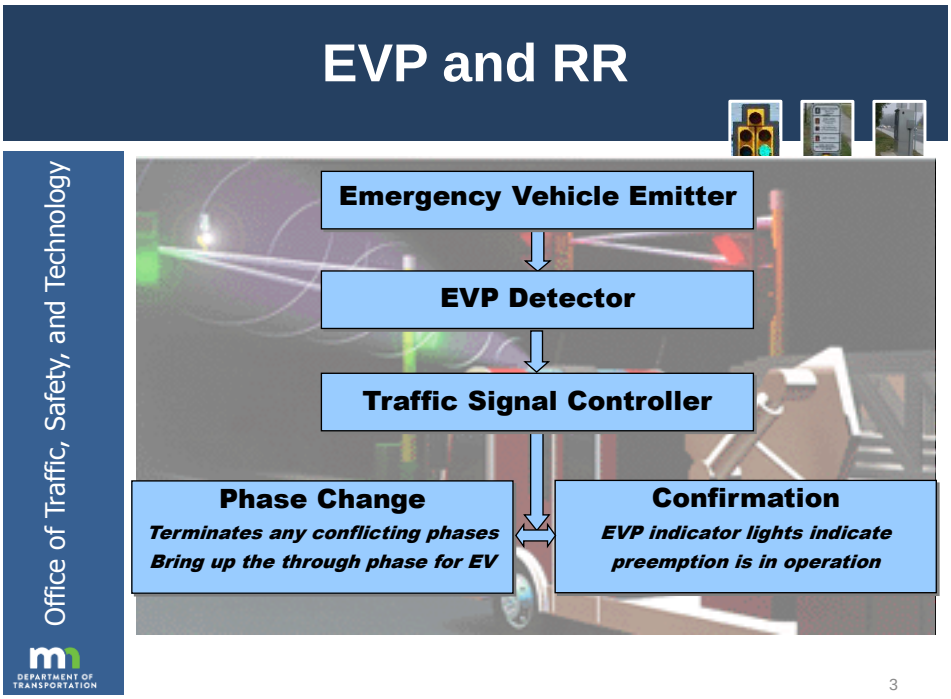
There are three common types of preemption, based on different reasons:

- Emergency Vehicle
- Railroad
- Transit Vehicle

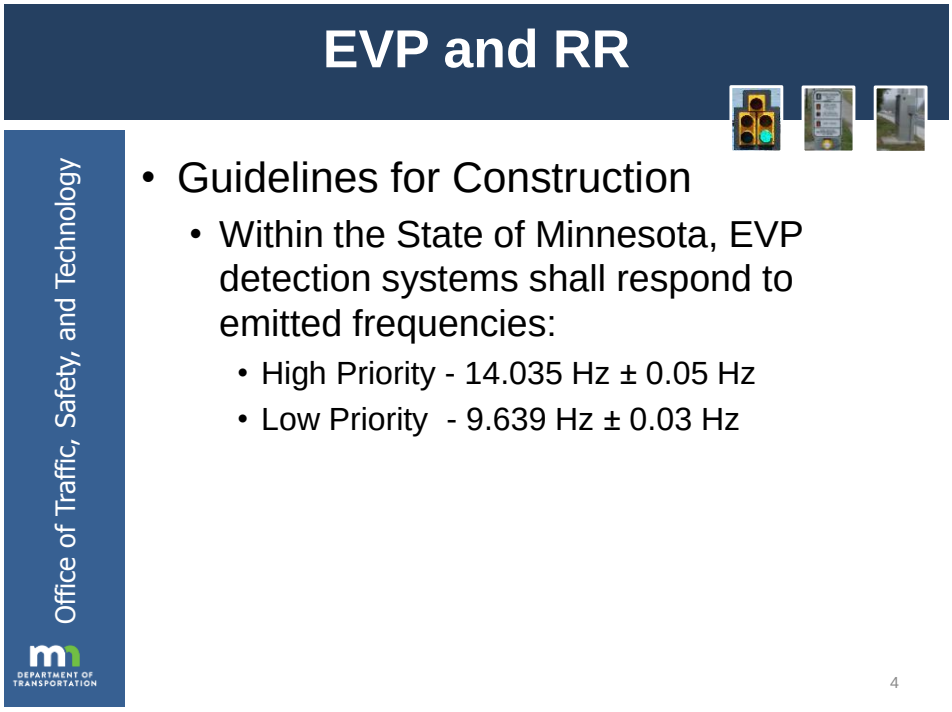
This topic will cover emergency vehicle and railroad preemption. A handout is included at the back of this topic on these topics.



This is the EVP definition.



The system works as follows: An authorized emergency vehicle approaching a signalized intersection en-route to a call has an activated emitter (a strobe light oscillating at a specified frequency). The oscillations are detected by an EVP detector mounted on the signal mast arm. The detector may be located elsewhere to increase the range. The signal controller terminates any conflicting phases to bring up the through phase for the authorized emergency vehicle. Indicator lights mounted on the mast arm indicate that preemption is in operation.



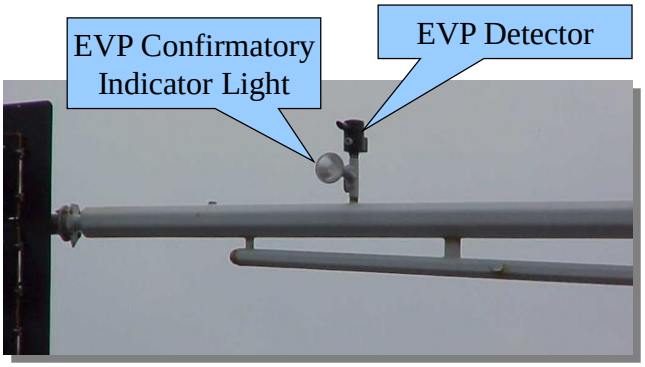
All newly constructed signals shall be wired for EVP. This includes running the necessary electrical conductors to the base of each pole or terminating in the mast arm as appropriate.

Traffic signals with EVP shall use confirmatory white indicator lights. The confirmatory light shall only be used during signal preemption. Railroad preemption shall have priority over all other types of preemption, including authorized emergency vehicles.

EVP and RR

Office of Traffic, Safety, and Technology

- Guidelines for Operation
  - EVP Confirmatory Indicator Light



5

The white/clear confirmatory indicator light shall be mounted, in most cases, on the signal mast arm, one indication light facing each direction of approach. The EVP confirmatory light shall remain dark (off) when the EVP Operation is not active. When the EVP is in operation, the indicator light shall flash or be steady under conditions defined below.

EVP and RR

Office of Traffic, Safety, and Technology

- Meaning of the Confirmatory Indicator Light
  - Steady EVP Confirmatory Indicator Light facing an approach means that the authorized emergency vehicle preemption has been received by the signal controller for that approach
  - Flashing EVP Confirmatory Indicator Light facing an approach means that the signal controller has received a call for preemption from an authorized emergency vehicle on a conflicting approach, and is responding to that call

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Note: The indications do not assign any right of way at the intersection.

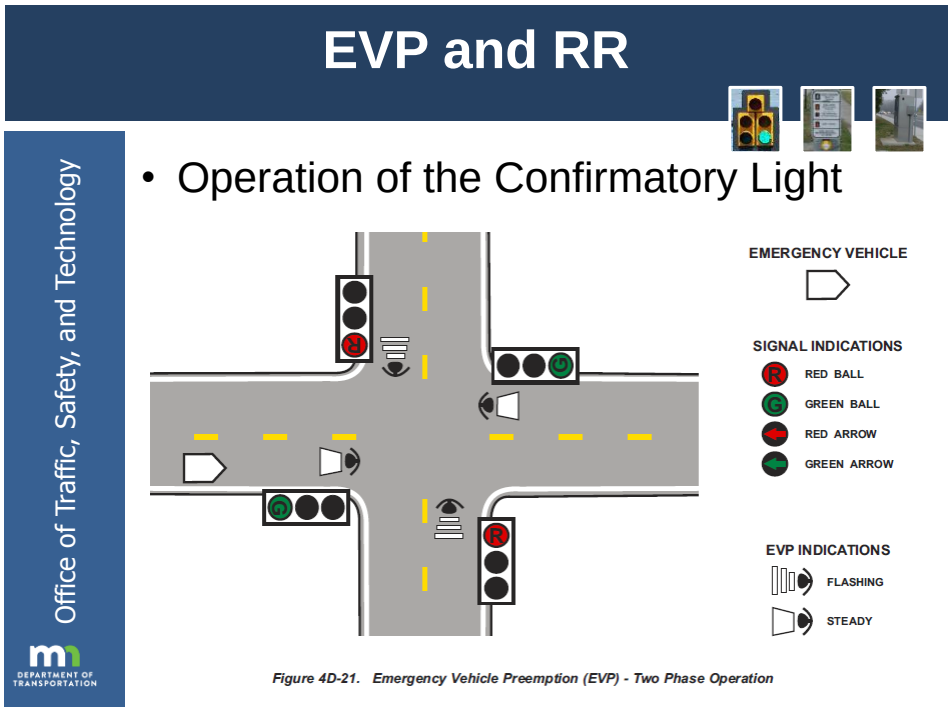

Figure 4D-21. Emergency Vehicle Preemption (EVP) - Two Phase Operation

This defines the meaning of the confirmatory light.

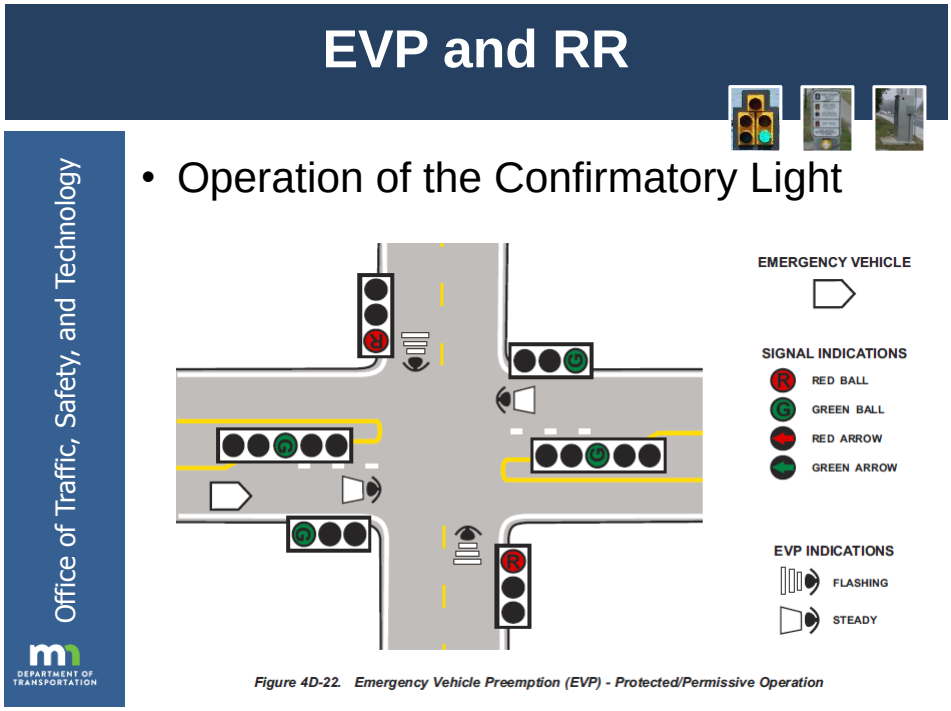

Figure 4D-22. Emergency Vehicle Preemption (EVP) - Protected/Permissive Operation

The approach that is preempted will receive a steady confirmatory light along with the opposing approach. The controller will cycle through to bring up the circular green indications. The conflicting approaches will receive flashing confirmatory lights and circular red indications.

EVP and RR

Office of Traffic, Safety, and Technology

- Operation of the Confirmatory Light

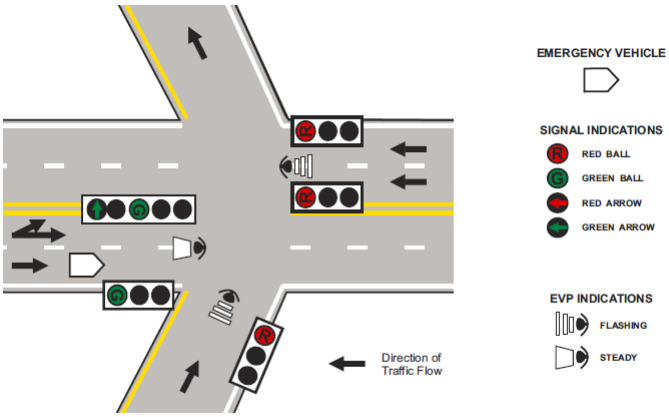

Figure 4D-23. Emergency Vehicle Preemption (EVP) - Ramp/One-Way/T-Intersection Protected/Permissive Operation

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The authorized emergency vehicle's approach shall receive a steady confirmatory indication light along with the opposing approach. The controller shall cycle through to bring up the circular green signal indication. The left turn green arrow is not given on the preempted approach since a permissive green ball for the opposing flow would have to be terminated first. An opposing left turner, seeing the signal go to yellow, might mistakenly assume that the preempted approach was also yellow, and turn into the oncoming traffic proceeding on a green. This is referred to as a "left turn trap." To avoid this, the left turn green arrow is not given to any approach.

The operation of this intersection, under preemption, is similar to that of a two-phase intersection. Conflicting approaches shall receive flashing confirmatory indication lights and circular red signal indications

EVP and RR

Office of Traffic, Safety, and Technology

- Operation of the Confirmatory Light

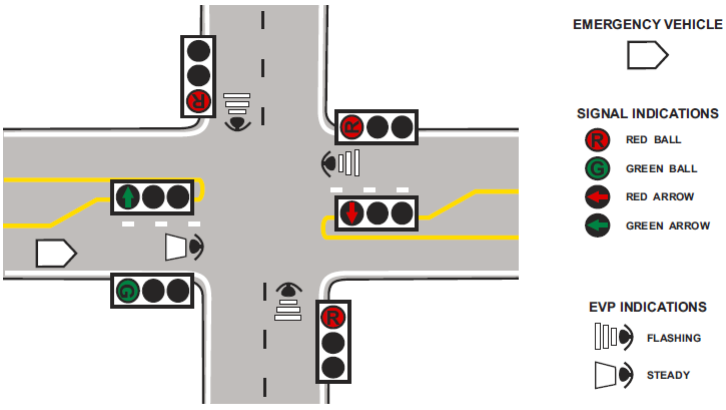

Figure 4D-24. Emergency Vehicle Preemption (EVP) - Protected Operation

The authorized emergency vehicle's approach shall receive a steady confirmatory indicator light, a protected left turn green arrow, and a circular green. The opposing and conflicting approaches shall receive flashing confirmatory indicator lights and red indications.

EVP and RR

Office of Traffic, Safety, and Technology

- Operation of the Confirmatory Light

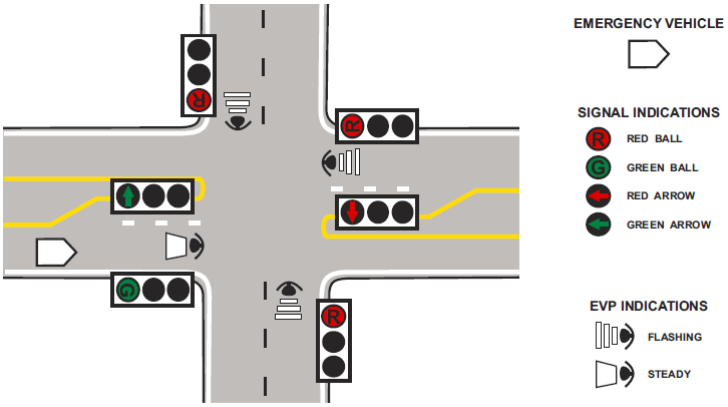

Figure 4D-24. Emergency Vehicle Preemption (EVP) - Protected Operation

The authorized emergency vehicle's approach shall receive a steady confirmatory indicator light, a protected left turn green arrow, and a circular green. The opposing and conflicting approaches shall receive flashing confirmatory indicator lights and red indications.

Refer to the MN MUTCD for additional details.

EVP and RR

Office of Traffic, Safety, and Technology

- Railroad Preemption
  - Railroad preemption is a system installed on traffic signals which allows trains or Light Rail Transit (LRT) vehicles to preempt the signal and travel through the intersection in a safe and timely manner

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This is the railroad preemption definition.

EVP and RR

Office of Traffic, Safety, and Technology

- Guidelines for Preemption
  - If either of the following conditions are present, consideration should be given to interconnect the traffic signal and railroad grade crossing:
    - Highway traffic queues that have the potential for extending across a nearby rail crossing
    - Traffic queued from a downstream railroad grade crossing that have the potential to interfere with an upstream signalized intersection

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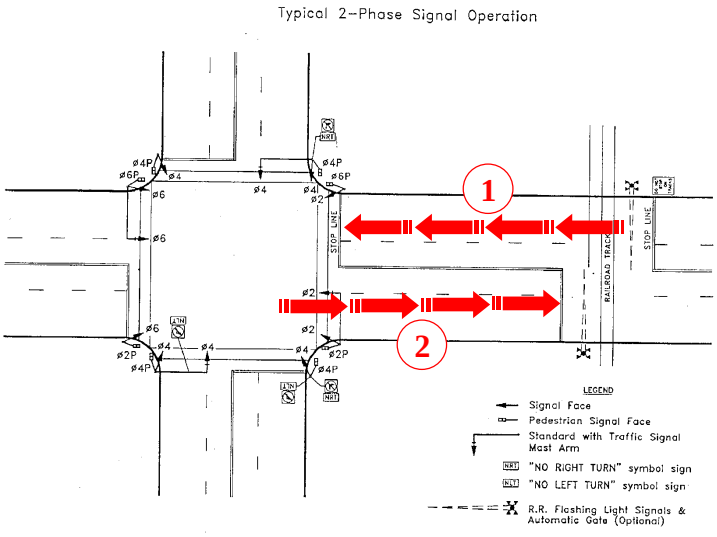
The preemption conditions are described below (next slide).

EVP and RR

Office of Traffic, Safety, and Technology



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Condition 1: Highway traffic queues behind the intersection stop line, and has the potential to block the railroad tracks.

Condition 2: Highway traffic queues behind the railroad grade crossing stop line, and has the potential to interfere with the signalized intersection. (Some vehicles stacked in the middle of the intersection).

EVP and RR

Office of Traffic, Safety, and Technology

- Guidelines for Design
  - When the determination has been made to preempt the traffic signal for a train, many items need to be considered
  - Some are listed here:
    - distance between the traffic signal and the grade crossing
    - intersection geometry
    - track orientation
    - approach speed of train
    - etc.

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Things to consider for preemption.

EVP and RR

Office of Traffic, Safety, and Technology

- Guidelines for Operation
  - Goal 1: Permit traffic to clear the tracks before the train reaches the crossing
  - Goal 2: Clear the traffic at the intersection

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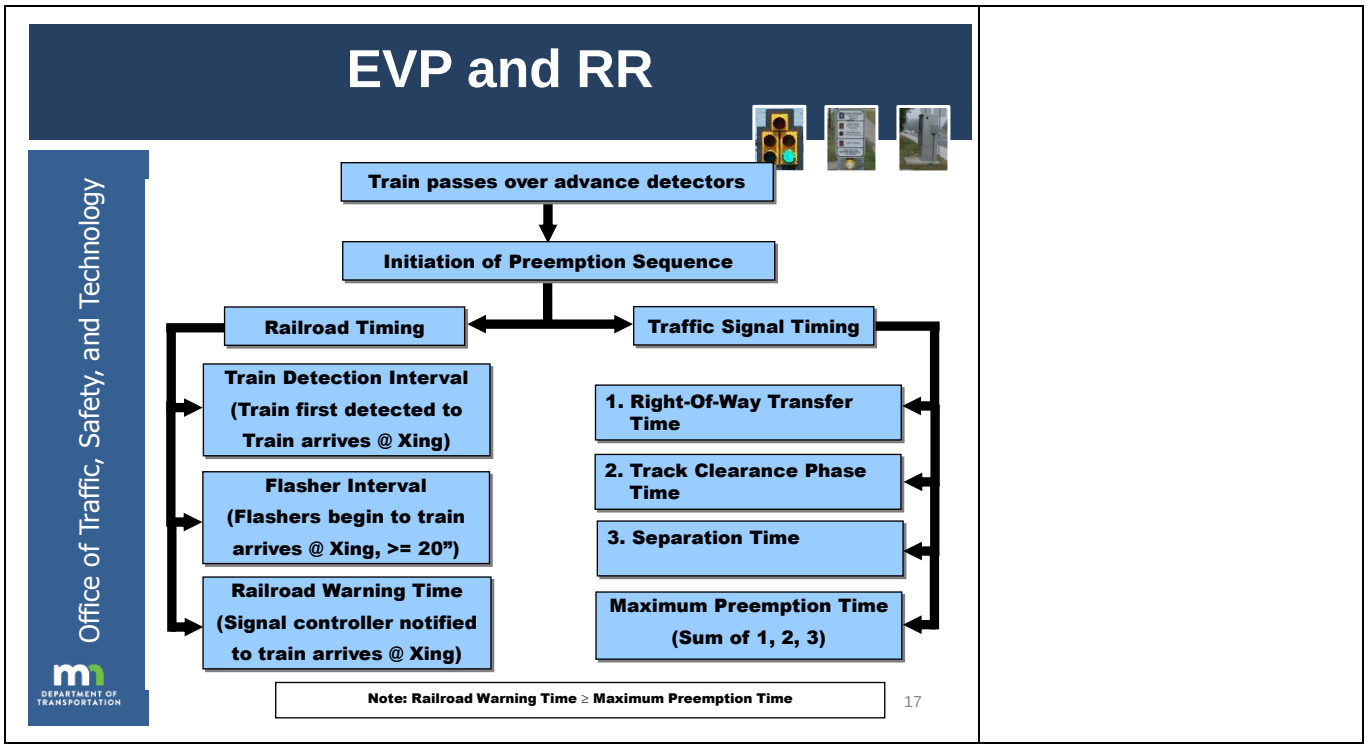
Guidelines for operation; goals.



GUIDELINES FOR OPERATION

The MMUTCD (Section 8C-6) requires that "The preemption sequence initiated when the train first enters the approach circuit, shall at once bring into effect a highway signal display which will permit traffic to clear the tracks before the train reaches the crossing. The preemption shall not cause any short vehicular clearances and all necessary vehicular clearances shall be provided. However, because of the relative hazards involved, pedestrian clearances may be abbreviated in order to provide the track clearance display as early as possible. After the track clearance phase, the highway intersection traffic control signals should be operated to permit vehicle movements that do not cross the tracks, but shall not provide a through circular green or arrow indication for movements over the tracks".

If the traffic signal is equipped with emergency vehicle preemption, the confirmation lights shall flash for all approaches during the preempt sequence.

TRAFFIC SIGNAL TIMING

Maximum Preemption Time

The Maximum Preemption Time is the amount of time needed following initiation of the preemption sequence for the highway traffic signals to complete the entire sequence to clear the crossing within the minimum track clearance distance, of any vehicles prior to the arrival of the train at the crossing. This is the total of the Right-of-Way Transfer Time, Track Clearance Phase Time and Separation Time. A tabulation of the calculation appears below.

Right-Of-Way Transfer Time

Equipment Response	_____ seconds
Pedestrian Clearance Time	_____ *seconds*
Minimum Green on Conflicting Phase	_____ *seconds*
Leading Flash Time of AWF (if present)	_____ *seconds*
Critical Phase Movement (Longer of Pedestrian Clearance or Min Green or Leading Flash Time of AWF)	_____ seconds

Yellow Change Interval* _____ seconds
Red Clearance* _____ seconds
Right-of-Way Transfer Time (Subtotal) _____ seconds
*if not included in the Pedestrian Clearance Time

Track Clearance Phase Time

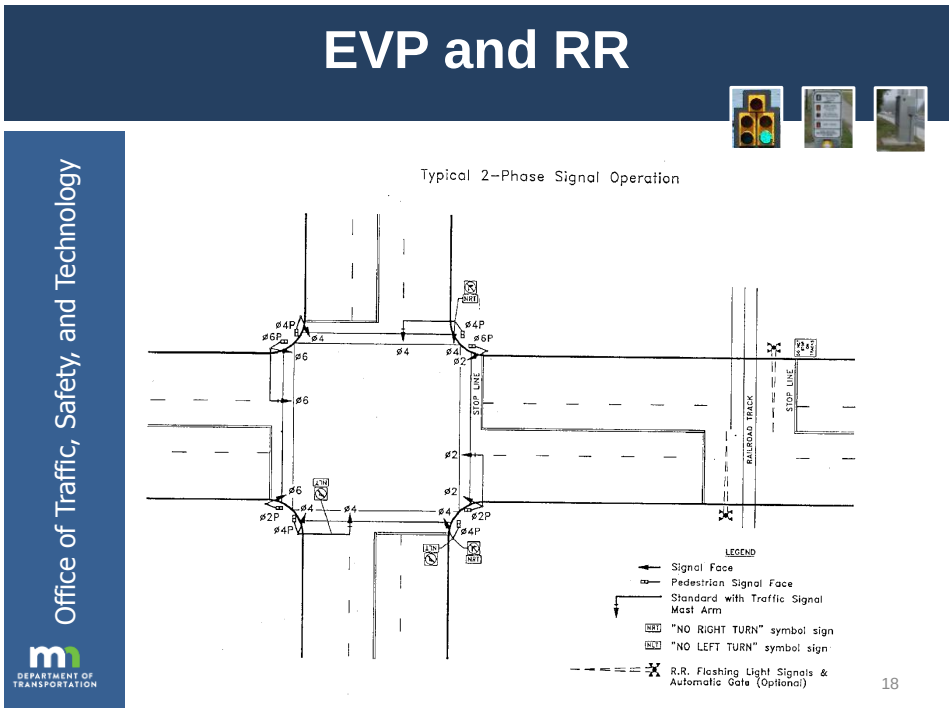
Dissipation of queued vehicles, per lane _____ seconds
Queue Clearance Time _____ *seconds*
Track Clearance Phase Time (Dissipation or Clearance Time) _____ seconds

Separation Time (typically 4-8 seconds) _____ seconds

Maximum Preemption Time _____ seconds
(Sum of the Right-of-Way Transfer Time, Track Clearance Phase Time and Separation Time)

RAILROAD TIMING

Railroad timing has to make sure that the Railroad Warning Time must be greater than or at least equal to the Maximum Preemption Time of traffic signal. At some locations, the Railroad Warning Time, the Train Detection Interval, and the Flasher Interval may all be the same.



This is the operation explanation diagram.

EVP and RR

Office of Traffic, Safety, and Technology

- Railroad Crossing

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This is a field picture of railroad preemption.

EVP and RR

Office of Traffic, Safety, and Technology

- Railroad Cabinet

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This is a field picture of a railroad cabinet.

Handouts

EVP handout from MN MUTCD (Page 4D-40 to 4D-44)

Railroad Preemption handout from the Traffic Signal Timing and Coordination Manual

For the latest version, please visit:

www.dot.state.mn.us/trafficeng/publ/index.html

STANDARD:

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

SUPPORT:

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.

4D.27 Preemption and Priority Control of Traffic Control Signals

OPTION:

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.

Preemption or priority control of traffic control signals may also be a means of assigning priority right-of-way 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.

SUPPORT:

Refer to applicable state statutes and local ordinances that may define which vehicles are authorized to preempt traffic signals or to request priority at traffic signals.

Preemption control (see definition in Section 1A.13) is typically given to trains, boats, emergency vehicles, and light rail transit.

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 towards the tracks during the approach or passage of rail traffic

Priority control (see definition in Section 1A.13) is typically given to certain non-emergency vehicles such as light-rail transit vehicles operating in a mixed-use alignment and buses.

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 in remaining on schedule; and
B. Special phasing to assist public transit vehicles in entering the travel stream ahead of the platoon of traffic.

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.

STANDARD:

Strobe actuated preemption and priority detection systems shall respond to emitted frequencies:

Preemption - 14.035 Hz ± 0.05 Hz
Priority - 9.639 Hz ± 0.03 Hz

Railroad preemption shall have priority over all other types of preemption and priority, including authorized emergency vehicles.

GUIDANCE:

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

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:

A. High priority preemption, including trains and semi-exclusive alignment light rail crossings where the light rail transit movement is not controlled by a traffic control signal or a light rail transit signal.
B. Emergency vehicle preemption.
C. Transit priority, including buses and semiexclusive or mixed-use alignment light rail crossings where the light rail transit movement is controlled by a traffic control signal or a light rail transit signal.

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 8C.11 and as illustrated in Figure 8C-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. Bus rapid transit in semi-exclusive or mixed-use alignments.

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

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 conflict with the vehicle making the request.

OPTION:

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; and
E. Responding directly to initial or dwell period.

4D-27.1 Operation of Preemption

STANDARD:

During the transition into preemption control:

A. The yellow change interval, and any red clearance interval that follows, shall not be shortened or omitted.
B. The shortening or omission of any pedestrian walk interval and/or pedestrian change interval shall be permitted.
C. The return to the previous green signal indication shall be permitted following a steady yellow signal indication in the same signal face, omitting the red clearance interval, if any.

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

A. The shortening or omission of any yellow change interval, and of any red clearance interval that follows, shall not be permitted.
B. A signal indication sequence from a steady yellow signal indication to a green signal indication shall not be permitted.

GUIDANCE:

If the pedestrian change interval is shortened during the transition into preemption control, it should not be shortened below the minimum pedestrian change interval time described in Section 4E.6.

STANDARD:

All newly constructed signals shall be wired for Emergency Vehicle Preemption (EVP). This includes running the necessary electrical conductors to the base of each pole or terminating in the mast arm as appropriate.

Traffic signals with EVP shall use confirmatory white/clear indicator lights. The confirmatory lights shall only be used during signal preemption.

A. A steady confirmatory indicator light facing an approach shall mean that the authorized emergency vehicle preemption has been received by the signal controller for that approach.
B. A flashing confirmatory indicator light facing an approach shall mean that the signal controller has received a conflicting preemption call and cannot respond to the preemption from the authorized emergency vehicle on the approach.

SUPPORT:

The purpose of the confirmatory indicator light is to verify to the authorized emergency vehicle driver that the controller has received the preemption call, to indicate which approach will be served under the preemption, or to verify that a train has preempted the operation of the signal. The confirmatory indicator light does not assign any right of way at the intersection. The driver of the emergency vehicle is required to respond to the traffic control signal indications in accordance with applicable statutes and ordinances.

GUIDANCE:

A time limit for which an emergency vehicle can preempt the traffic control signal should be used if the control equipment provides this capability.

SUPPORT:

This time limit can be set either in the controller or in the preemption equipment. This time limit is to prevent the inadvertent continuous activation of preemption by a stopped authorized emergency vehicle with the strobe left on.

STANDARD:

When the EVP is active, the indicator light shall flash or be steady, and the signal indications shall be displayed as indicated under the following types of operation:

A. Two Phase Operation
The authorized emergency vehicle's approach

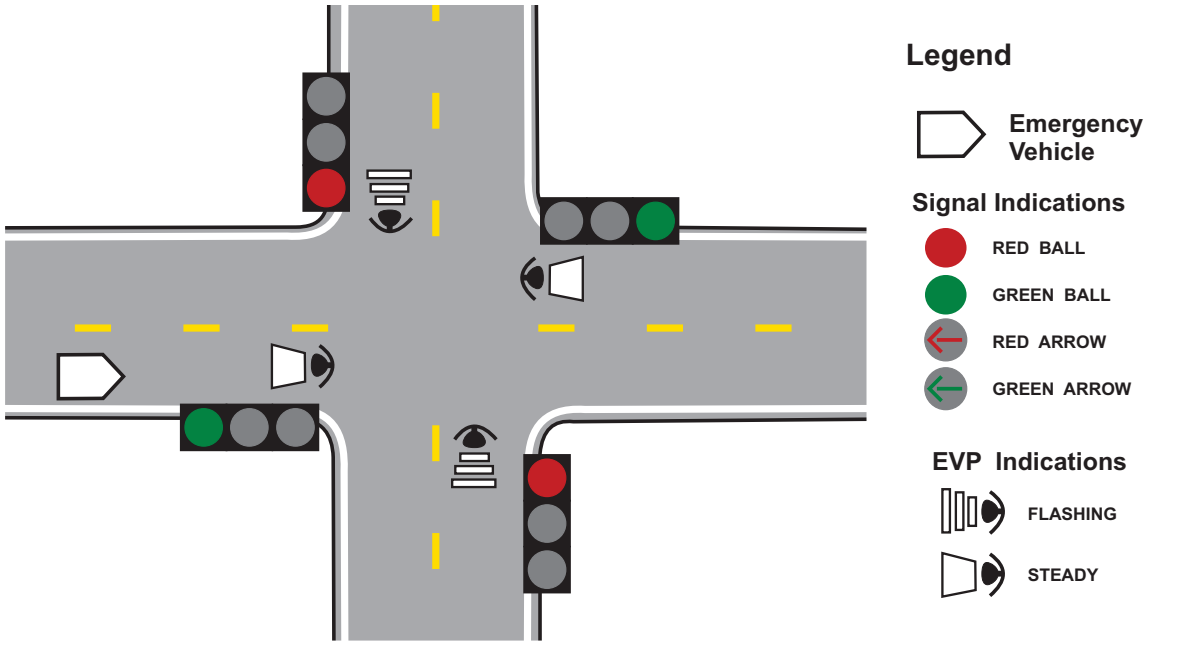


Figure 4D-21. Emergency Vehicle Preemption (EVP) - Two Phase Operation

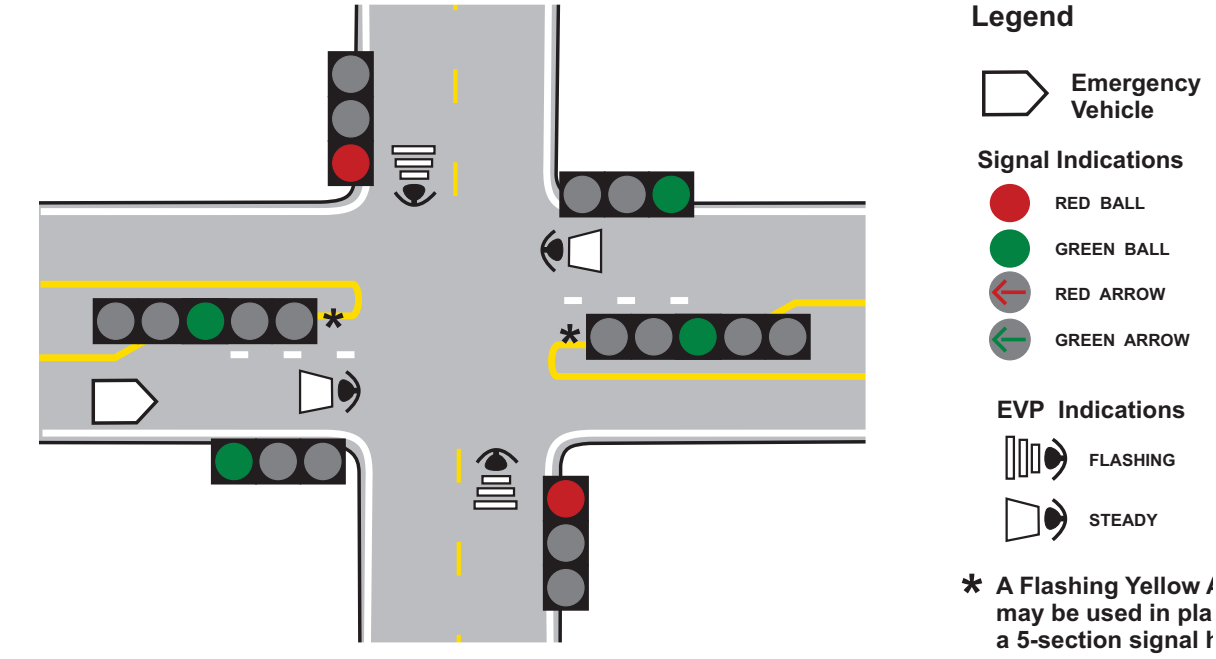


Figure 4D-22. Emergency Vehicle Preemption (EVP) - Protected/Permissive Operation

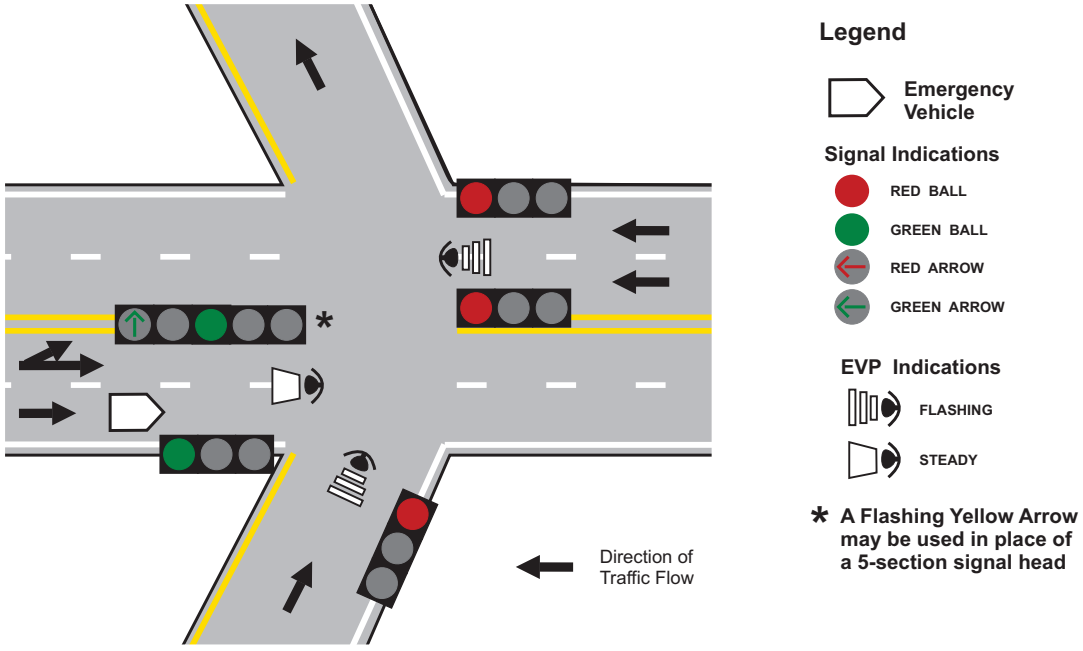


Figure 4D-23. Emergency Vehicle Preemption (EVP) - Ramp/One-Way/T-Intersection Protected/Permissive Operation

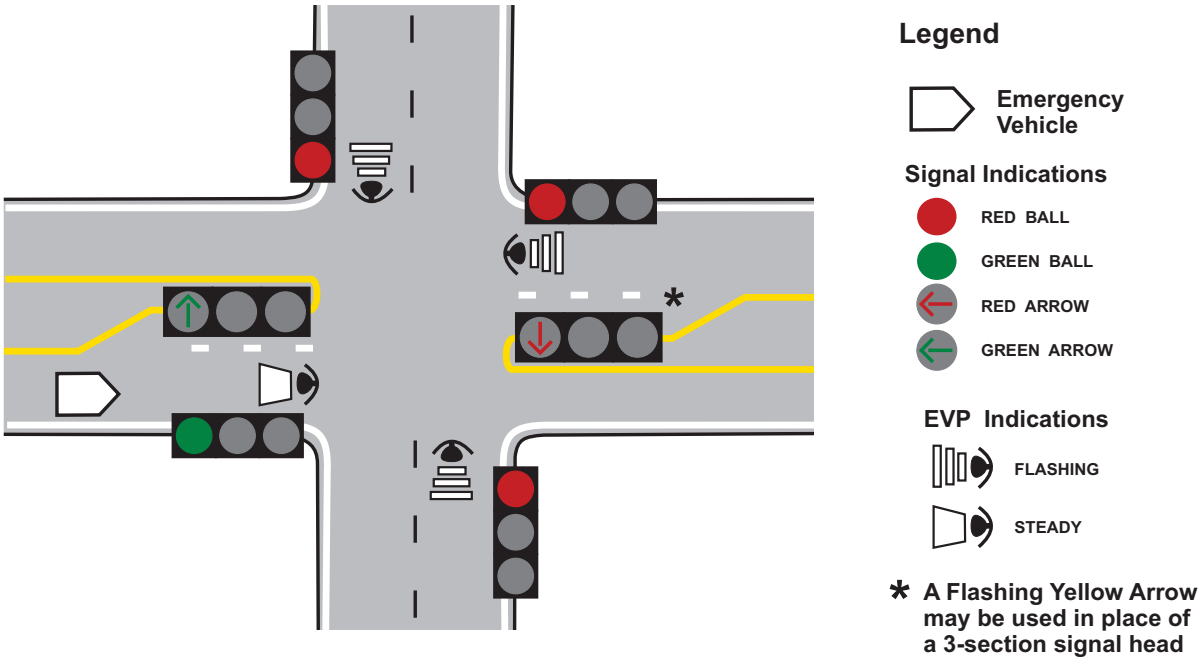


Figure 4D-24. Emergency Vehicle Preemption (EVP) - Protected Operation

shall receive a steady confirmatory light along with the opposing approach. The controller shall cycle through to bring up the circular green indications. The conflicting approaches shall receive flashing confirmatory lights and circular red indications. (See Figure 4D-21).

2. Multi-phase Protected/Permissive Operation

   The authorized emergency vehicle's approach shall receive a steady confirmatory indication light along with the opposing approach. The controller shall cycle through to bring up the circular green signal indication. The left turn green arrow is not given on the preempted approach since a permissive green ball for the opposing flow would have to be terminated first. An opposing left turner, seeing the signal go to yellow, might mistakenly assume that the preempted approach was also yellow, and turn into the oncoming traffic proceeding on a green. This is referred to as a "left turn trap." To avoid this, the left turn green arrow is not given to any approach. The operation of this intersection, under preemption, is similar to that of a two-phase intersection. Conflicting approaches shall receive flashing confirmatory indication lights and circular red signal indications. (See Figure 4D-22).

3. Multi-phase Protected/Permissive Operation with Ramps and One-Way Streets

   The authorized emergency vehicle's approach shall receive a steady confirmatory indicator light, a protected left turn green arrow, and a circular green. The opposing and conflicting approaches shall receive flashing confirmatory indicator lights and red indications. (See Figure 4D-23).

4. Multi-phase Protected Operation

   The authorized emergency vehicle's approach shall receive a steady confirmatory indicator light, a protected left turn green arrow, and a circular green. The opposing and conflicting approaches shall receive flashing confirmatory indicator lights and red indications. (See Figure 4D-24).

5. Railroad Preemption Operation

   When preempted by trains or light rail transit vehicles at a railroad intersection, all confirmatory indicator lights shall flash.

OPTION:

On an approach to a multi phase protected/permissive intersection, the authorized emergency vehicle's approach may receive a steady confirmatory indicator light, a protected left turn green arrow, and a circular green, with opposing and conflicting approaches receiving flashing confirmatory indicator lights and red indications, if the traffic signal first transitions to an all red indication for all approaches.

On an approach to a multi phase protected operation intersection, if roadway geometry, signal operation, or preemption recognition distance is insufficient to clear left turning vehicles ahead of the authorized emergency vehicle, the authorized emergency vehicle's approach and the opposing approach may receive a steady confirmatory indicator light and a circular green and red left turn arrow, with all conflicting approaches receiving a flashing confirmatory indicator light and red indications. This alternative is permitted in low speed applications where clearing the left turn bay is a problem.

GUIDANCE:

If a traffic control signal 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.

4D.27.2 Operation of Priority

STANDARD:

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 4E.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.

Confirmatory indicator lights shall not be displayed for priority operation. If confirmatory indicator lights exist at an intersection for preemption confirmation, a priority request shall not alter the preemption operation of the confirmatory indicator lights.

4D.28 Flashing Operation of Traffic Control Signals - General

STANDARD:

The light source of a flashing signal indication shall be flashed continuously at a rate of not less than 50 nor more than 60 times per minute.

4.12 Guidelines for the Inspection and Operation of Railroad Preemption at Signalized Intersections

Introduction

This section provides guidelines and recommendations for the installation, operation and inspection of traffic signals that are preempted either by trains or by Light Rail Transit (LRT) vehicles utilizing preemption. Yearly inspections will be performed and submitted to the Office of Freight, Railroads & Waterways.

Scope

The guidelines and procedures contained in this section apply to MnDOT, and to county and city agencies through the state aid process. MnDOT district offices may assist local agencies in performing inspections, if requested.

The responsibility for the operation of the highway/railroad preempted traffic signals remains with the district, county or city having operational jurisdiction. Neither an inspection nor these guidelines substitute for sound engineering judgment in the operation of traffic signals.

These are general guidelines and should be used only as a guide. Other factors at each location must be considered in applying these guidelines. The Minnesota Manual on Uniform Traffic Control Devices (MN MUTCD), Traffic Control Devices Handbook, Railroad-Highway Grade Crossing Handbook (FHWA-TS-86-215), and the Institute of Transportation Engineers' Preemption of Traffic Signals at or Near Railroad Grade Crossings with Active Warning Devices should be referred to for additional guidance.

Guidelines for Preemption

If either of the following conditions are present, consideration should be given to interconnect the traffic signal and railroad grade crossing:

A. Highway traffic queues that have the potential for extending across a nearby rail crossing.

B. Traffic queued from a downstream railroad grade crossing that have the potential to interfere with an upstream signalized intersection.

The 1991 version of the Minnesota Manual on Uniform Traffic Control Devices, specifies that the recommended distance between traffic signal and grade crossing for interconnection is 200 feet (65 meters). Recent research has found this distance to be inadequate. The following formulas provide a method for estimating the queue length that can be expected on the approach. If the queue length exceeds the storage between the intersection stop bar and 6 feet (2 meters) from the nearest rail, the railroad signal and the traffic signal should be interconnected.

A method for estimating queue length (with about 95 percent certainty) is as follows:

$$L=2qrv(1+p)$$

Where: L = length of queue, in feet or meters per lane;

q = flow rate, average vehicles per lane per second;

r = effective red time (time which the approach is red or yellow per cycle);

v = passenger vehicle length, assume 25 feet or 7.5 meters;

p = proportion of trucks;

The 2 is a random arrival factor.

This formula provides a good estimate of queue lengths, where the volume to capacity (v/c) ratio for the track approach is less than 0.90. However, for v/c ratios greater than 0.90, some overflow queues could occur as a result of fluctuations in arrival rates. To compensate for this condition, it is suggested that one vehicle should be added for each percent increase in the v/c ratio over 0.90. Accordingly, in cases where the v/c ratio ranges from 0.90 to 1.00, the following formula applies:

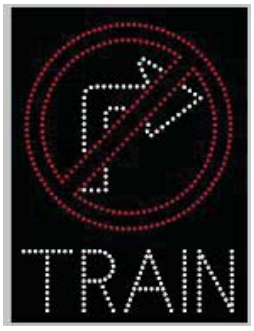
$$L=(2qr+\Delta x)(l+p)v$$

Where $\Delta x = l00(v/c\ ratio - 0.90)$. Thus, for a *v/c* ratio 0.95, Δx would be 5 vehicles in the above formula. This formula cannot be used if the *v/c* ratio ≥1.0, then a field queue study will be needed in that case.

Queue lengths for through traffic and for left turns should both be checked to determine which queue is the most critical.

Guidelines for Design

When the determination has been made to preempt the traffic signal for a train, many items need to be considered. Some are listed here: distance between the traffic signal and the grade crossing, intersection geometry, track orientation, approach speed of train, train frequency, volume of vehicular traffic, vehicle type, pedestrian, and equipment at the intersection and grade crossing.



Blank out no right turn signs prohibiting right turns shall be used on all new signals to prohibit right turns towards the highway-grade crossing during preemption. This blank out turn sign should typically be placed on the far side pole or mast arm. Only one sign is required but additional blank out signs can be considered by the diagnostic team. Other mounting locations for the sign can be considered. The approach turning right over the track must have a dedicated right turn lane. The blank out sign shall be an R3-1 with the word "TRAIN" underneath. If the diagnostic team has determined that a blank out sign is not in the best interest of the traveling public, document why.

Short distances: Where the clear storage distance between the tracks and the highway intersection stop line is not sufficient to safely store a design vehicle like the longest, legal truck combination, or if vehicles regularly queue across the tracks, a pre-signal should be considered. An engineering study should be performed to support this recommendation. A pre-signal may also be beneficial if gates are not provided. This supplemental traffic signal should be carefully designed to avoid trapping vehicles on the tracks. Visibility-limited traffic signals at the intersection may be needed to avoid driver conflict and confusion. The DO NOT STOP ON TRACKS sign (R8-8) and STOP HERE ON RED sign (R10-6) of the MN MUTCD should also be used. Certain situations where gates are not present may also require prohibiting turns on red.

Guidelines for Operation

The MN MUTCD (Section 8C-6) requires that "The preemption sequence initiated when the train first enters the approach circuit, shall at once bring into effect a highway signal display which will permit traffic to clear the tracks before the train reaches the crossing. The preemption shall not cause any short vehicular clearances and all necessary vehicular clearances shall be provided. However, because of the relative hazards involved, pedestrian clearances may be abbreviated in order to provide the track clearance display as early as possible. After the track clearance phase, the highway intersection traffic control signals should be operated to permit vehicle movements that do not cross the tracks, but shall not provide a through circular green or arrow indication for movements over the tracks".

If the traffic signal is equipped with emergency vehicle preemption, the confirmation lights shall flash for all approaches during the preempt sequence.

Guidelines for Inspection

Existing highway/railroad preempted traffic signals shall be inspected on an annual basis. It is the responsibility of the roadway authority that has responsibility for the operation of the traffic signal to initiate the annual inspection. A copy of the completed inspection forms shall be forwarded to the Office of Freight, Railroads & Waterways on an annual basis.

The District Traffic Engineer will ensure that each location under MnDOT jurisdiction is inspected. Through the State Aid program, cities and counties are required to perform annual inspections.

The rail authority shall be contacted prior to inspection and a representative shall be present during each inspection. This joint inspection is critical, as the operation of railroad preemption systems is dependent on both the railroad and highway agencies.

The inspection should be done while a train passes through the area if possible.

During this inspection, a general review of the highway intersection and railroad crossing for proper signing, pavement markings, signals, sight distances, and changes in conditions should be made.

It is also advised that all traffic signals without railroad preemption need to be reviewed when traffic patterns change, see if additional traffic control/RR preemption is needed.

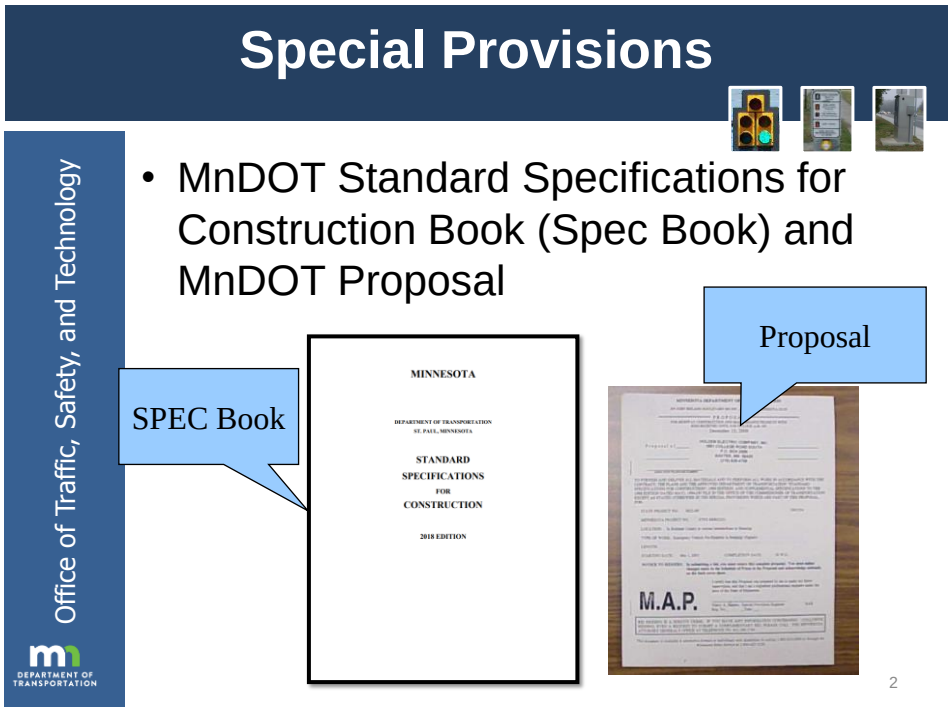
Annual Inspection Form

The following information is a printout of the **Railroad Preemption Timing and Annual Inspection Form** (xls). This information is available from the MnDOT website:

www.dot.state.mn.us/trafficeng/signals/signalworksheets.html

TOPIC 12: SPECIAL PROVISIONS

This topic will cover the Standard Specifications for Construction Book (Spec Book), the Contract Proposal and Supplemental Agreements.



The "Spec Book" contains standard specifications to be used and referred to in the design of traffic signal plans and in the preparing of traffic signal Special Provisions. Plan designers need to be aware of the specifications contained in the Spec Book that may apply to their individual project.

Each individual project will have a Contract Proposal. The Contract Proposal contains many important documents, including the Special Provisions for the Project.

Special Provisions

Office of Traffic, Safety, and Technology

- THE SPEC BOOK:
  - Contains both US Customary and metric units
  - Contains modifications to the prior spec book

3

The Spec Book includes both "metric" and "non-metric" conversions. The Spec Book also includes numerous modifications to the former Spec Book.

Special Provisions

Office of Traffic, Safety, and Technology

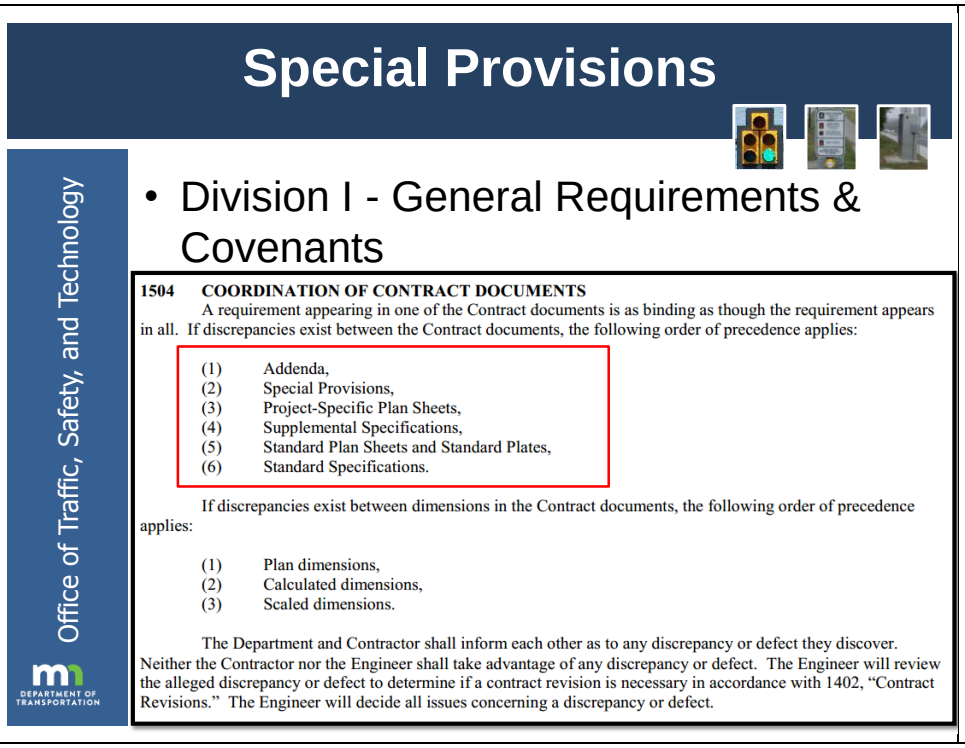
- "Spec. Book" Format
  - Three Divisions
    - Division I: General Requirements and Covenants
    - Division II: Construction Details
    - Division III: Material

4

Division I Specifications are labeled as 1000 series (1101 thru 1911).

Division II specifications are labeled as 2000 series (2021 thru 2581).

Division III specifications are labeled as 3000 series (3101 thru 3985).



"1504 COORDINATION OF CONTRACT DOCUMENTS

A requirement appearing in one of the Contract documents is as binding as though the requirement appears in all. If discrepancies exist between the Contract documents, the following order of precedence applies:

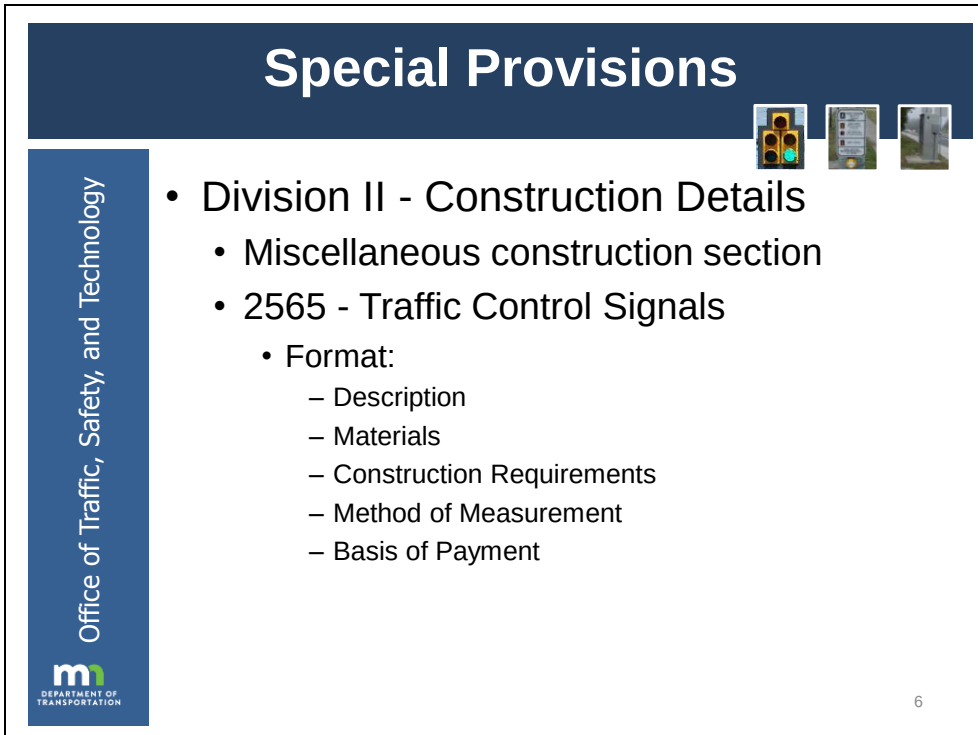
(1) Addenda,
(2) Special Provisions,
(3) Project-Specific Plan Sheets,
(4) Supplemental Specifications,
(5) Standard Plan Sheets and Standard Plates,
(6) Standard Specifications.

If discrepancies exist between dimensions in the Contract documents, the following order of precedence applies:

(1) Plan dimensions,
(2) Calculated dimensions,
(3) Scaled dimensions.

The Department and Contractor shall inform each other as to any discrepancy or defect they discover.

Neither the Contractor nor the Engineer shall take advantage of any discrepancy or defect. The Engineer will review the alleged discrepancy or defect to determine if a contract revision is necessary in accordance with 1402, "Contract Revisions." The Engineer will decide all issues concerning a discrepancy or defect."



Division II contains MnDOT 2565 (Traffic Control Signals).

The format of MnDOT 2565 is as follows:

***Description**:*

- has a General information section.
- has a Definitions section.

Materials:

- has a General information section.
- specifies various materials, including references to Division III of the Spec Book.

Construction Requirements:

- has a General information section
- specifies the requirements for actually constructing a traffic control signal system.

***Method of Measurement*:**

- traffic control signal systems are measured as an integral unit complete in place and operating with the complete installation at *one intersection* being considered one unit.

Basis of Payment:

- There is a payment schedule listed in this section that shows the Item No., Item, and Unit. There is only one item used for traffic control signal systems in the Spec Book, however, signal system projects do use other "individual" pay items. These pay items are written as part of the Special Provisions.

Special Provisions

Office of Traffic, Safety, and Technology

- Division III - Materials
  - Electrical Materials Section
    - Conduit (3801 thru 3803)
    - Lighting Luminaires (3810)
    - Photoelectric Controls (3812)
    - EVP Equipment (3814)
    - Electric Cables and Conductors (3815)
    - Mast Arm Pole Standards (3831)
    - Traffic Signal Pedestals (3832)
    - Pedestrian Push Buttons and Signs (3833)
    - Pedestrian Signal Faces (3835)
    - Electrical Service Equipment (3837)
    - Electrical Junction Boxes (3838)

7

Division III includes a section entitled "Electrical Materials" which contains various material specifications for traffic control signal systems. Many of these material specifications are referred to by MnDOT 2565. The format of these material specifications are divided into: Scope, Requirements, and Inspection and Testing.

Special Provisions

Office of Traffic, Safety, and Technology

- Other national and local standards specified in the book
  - AASHTO
  - ITE
  - NEC
  - RUS
  - ASTM
  - ICEA
  - NEMA
  - UL

All electrical equipment to be furnished by a Contractor shall conform to other regulations, standards, and Codes as specified in the "Spec Book"

8

AASHTO, American Association of State Highway and Transportation Officials

ASTM, American Society of Testing and Materials

ITE, Institute of Transportation Engineers

ICEA, Insulated Cable Engineers Association

NEC, National Electrical Code

NEMA, National Electrical Manufacturers Association

RUS, Rural Utilities Service

UL, Underwriter Laboratories, Inc.

Special Provisions

Office of Traffic, Safety, and Technology

- Supplemental Specifications
  - Additions and revisions to the standard specifications that are approved after the Spec Book has been printed and distributed
  - The plan and the proposal need to state if supplemental specifications apply to your specific project

9

Supplemental specifications are additions and revisions to the standard specifications that are approved after the standard specification book has been printed and distributed. They are published separately (usually in paperback booklet form) until the next updated Spec Book is published and released. The Plan and Proposal for each specific project will state if there are supplemental specifications that apply.

Special Provisions

Office of Traffic, Safety, and Technology

- The Proposal
  - Addendums
  - Notice to Bidder
  - Special Provisions by Division (2565)
  - Attachments
  - Contract Schedule (Bid Prices)

10

Each MnDOT project has a proposal.

Special Provisions

Office of Traffic, Safety, and Technology

- Contract Proposal
  - Contain special “provisions” by Division
  - Division “SS” covers signal systems
  - Division “SS” may be formatted into more than two “SS” sections

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Each Proposal contains Special Provisions by Division, for example:

Division S – General Requirements

Division SL – Electric Street Lighting

Division SS – Traffic Control Signals

Division ST – Traffic Signs and Devices

Division SZ – Freeway Traffic Management Systems

Special Provisions

Office of Traffic, Safety, and Technology

- Special Provisions
  - Special Provisions are “additions and revisions” to the Standard and Supplemental
  - Specifications covering conditions peculiar to an individual project

12

Special Provisions are just that: **“SPECIAL”** provisions. If an item(s) is adequately addressed or specified in the Spec Book, Standard Plates, Plan, or other Contract documents, then that item(s) should not be duplicated within the Special Provisions.

Special Provisions

Office of Traffic, Safety, and Technology

- Division SS (Traffic Control Signals)
  - SS-1 Qualification of Workers
  - SS-2 Traffic Control Signals
  - SS-3 Emergency Vehicle Preemption (EVP) System
  - SS-4 Traffic Control Interconnection

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All signal system Special Provisions that are part of MnDOT projects or have State Aid money involved will have a SS-1 “Qualification of Workers” specification.

SS-3 EVP could be incidental to the traffic signal system and therefore be part of SS-2 “Traffic Control Signals”.

Special Provisions

Office of Traffic, Safety, and Technology

- Special Provisions Format
  - Traffic Control Signals:
    - Description
    - General
    - Materials
    - Construction Requirements
    - Measurement and Payment

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A typical set of Special Provisions for a signal system is formatted similar to the Spec Book; however, the actual format of the Special Provisions may vary somewhat when compared to the Spec Book format.

Special Provisions may also include detail drawings that are pertinent to the specific project.

The following is a closer look at a typical set of Special Provisions for a signal system:

Qualification of Workers

This section requires Signal and Lighting Certification for all Contractors' Supervisors and Foreman involved in the field installation of traffic signal and lighting system projects. This language is required in the Special Provisions for any project that involves MnDOT and State Aid projects.

Traffic Control Signals

Signal system Special Provisions will have a description paragraph of the work: what work is involved, location of project; and what documents the project shall be in accordance with.

Traffic Control Signals:

General Section:

This section will usually include a list of Department furnished materials being supplied to the Contractor and language specifying where the Contractor is to pick-up the Department furnished materials. This section may also include any Plan changes, notes to bidders, specifying whether or not an agreement will apply to the project, etc.

Materials Section:

This section will cover any material items that are not covered in other Contract documents, or language in other documents that needs to be modified for this specific project.

Construction Requirements:

This section contains language dealing with the actual construction of the signal system. Like the materials section, it will include language that modifies items in the Spec Book, Plan, or other Contract documents.

Measurement and Payment:

This section will specify exactly how the signal system will be measured and paid for. The pay items in this section need to match the pay item(s) listed on the estimated quantity sheet in the Plan.

The following is a "sample" pay item for a signal system set of Special Provisions:

> Removing and salvaging the existing traffic control signal system; furnishing and installing materials and electrical equipment; and installing Department furnished materials as specified herein, all to provide a complete operating new full-traffic-actuated traffic control signal system at the intersection of _____ and _____ in _____, _____ County as contained in these Special Provisions and in the Plans will be measured as an integral unit and paid for as specified in MnDOT 2565.4 and MnDOT 2565.5 respectively for Item No. 2565.511 (TRAFFIC CONTROL SIGNAL SYSTEM).

The majority of signal system Special Provisions are written by the MnDOT Office of Traffic Engineering for State let projects. Consultants, however, usually prepare the Special Provisions for consultant designed MnDOT projects.

Special Provisions

Office of Traffic, Safety, and Technology

- Addendums
  - Additional information, corrections, or deletions to Special Provisions, Plans, or the Spec Book after project has been put on sale, but before the actual letting
  - Addendums are sent out to those who have purchased Contract documents for the specific project
  - The addendums are included in the front portion of the "final" proposal for the project

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At times it may become necessary to provide additional information, corrections, additions, or deletions to the Special Provisions, Plans, and/or Spec Book after the Project is put on sale, but before the actual letting of the Project. This information is provided to bidders by creating an "Addendum". These addendums are then sent out to Contractors, suppliers, etc. that have purchased the Contract documents for the specific project. These addendums are sent out with enough lead time to allow bidders the opportunity to consider the addendum in preparing their bid. *All addendums will be located in the front portion of the MnDOT final project proposal.*

Special Provisions

Office of Traffic, Safety, and Technology

- Supplemental Agreements
  - Written after Contract underway
  - Negotiated between Contractor and project Engineer
  - Keep to minimum

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It is important that Plans and Special Provisions are clear, accurate, and adequately indicate the work that the Contractor is required to perform. However, when that does not happen, or if some item(s) is inadvertently omitted from the project documents, MnDOT will negotiate a supplemental agreement with the Contractor to rectify the situation. There are occasions when supplemental agreements are necessary due to field conditions that were not apparent at the time of the project design. It is, however, in the best interest of everyone to try and keep supplemental agreements to a minimum.

Handout

Sample Special Provisions (Select pages only)

For the most current sample, please visit:

http://www.dot.state.mn.us/trafficeng/signals/manual.html

HANDOUT

"2018 SAMPLE" TRAFFIC CONTROL SIGNAL SYSTEM SPECIAL PROVISIONS (November 16, 2017)

This "sample" set of Signal System Special Provisions will require editing (add, delete, modify, update, etc.) prior to use on a specific project. Some of the paragraphs included in these special provisions are project specific and may not be required on every project. Use the language when appropriate based on the plan and as directed in RED text.

All RED text must be removed from the special provisions prior to the special provisions being submitted for project letting.

DIVISION SS

SS-1. (2565) TRAFFIC CONTROL SIGNALS

This work consists of removing and salvaging, or disposing of the existing traffic control signal system; providing and installing materials and electrical equipment; and installing Department provided materials as specified herein, all for a complete operating new hardwire interconnected coordinated full-traffic-actuated traffic control signal system at the intersection of _____ (_____) and _____ in _____, _____ County, in accordance with the applicable provisions of MnDOT 2565; with the current edition of the National Electrical Code; with the Plans; and as follows:

--- OR ---

This work consists of removing, salvaging, or disposing of two existing traffic control signal systems; providing and installing materials and electrical equipment; and installing Department provided materials as specified herein, all to provide two complete operating new hardwire interconnected coordinated full-traffic-actuated traffic control signal systems as follows:

1. **SYSTEM "A"** - at the intersection of _____ (_____) and _____ in _____, _____ County, and

2. **SYSTEM "B"** - at the intersection of _____ (_____) and _____ in _____, _____ County,

In accordance with MnDOT 2565, the Plans, and as follows:

A. 2565 Definitions

Definitions are in accordance with Standard Specifications for Construction Section1103 and as follows:

1. Approved/Qualified Products List (APL)

2565 ABBREVIATIONS

D GLOSSARY OF ACRONYMS AND ABBREVIATIONS

Acronyms and abbreviation used in the Contract to represent full text in accordance with 1102 "Abbreviations and Measurement Units" and as shown in Table 2545-1:

Table 2565-1
Acronyms and Abbreviations Used

"2018 SAMPLE" TRAFFIC CONTROL SIGNAL SYSTEM SPECIAL PROVISIONS (November 16, 2017)

This "sample" set of Signal System Special Provisions will require editing (add, delete, modify, update, etc.) prior to use on a specific project. Some of the paragraphs included in these special provisions are project specific and may not be required on every project. Use the language when appropriate based on the plan and as directed in RED text.

All RED text must be removed from the special provisions prior to the special provisions being submitted for project letting.

Acronym or Short Form	Full Name or Meaning
APL	Approved/Qualified Products List

SS-2. MATERIALS REQUIREMENTS

SS-2.1 GENERAL

(None)

Ensure Division S Special Provisions "As-Builts" are included in the Division S Special Provisions. This would include the pay item 2011.601.
After the July 2015 Project letting date the As-Builts verbiage should automatically be included in Division S Special Provisions by MnDOT's Project Management & Technical Support Office.
Note required verbiage below in the measurement and payment section of these special provisions.
All Red text must be removed from the special provisions prior to the special provisions being submitted for project letting.

SS-2.2 MATERIALS

2.2.1 Department Provided Materials

The Department provides to the Contractor (at no expense to the Contractor) the following materials and electrical equipment for the Contractor to install:

1. One (1) traffic control signal cabinet each complete with actuated controller unit and all required signal control equipment.

2. Four (4) sets of anchor rods, nuts, and washers to mount the Department provided traffic control signal cabinet (one set = one anchor rod, nut, and washer).

3. One (1) 4-section rubber gasket to be installed between the bottom of each traffic control signal cabinet and the concrete foundation.

(The following language is to be used for required warning stickers on the backside of sign panels being installed on the signal system project. See additional verbiage under construction requirements. The Specification Writer must include the appropriate contact person and phone number to the following paragraph).

All Red text must be removed from the special provisions prior to the special provisions being

HANDOUT

HANDOUT

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submitted for project letting.

4. Warning stickers on new sign panels shall be in accordance with 2564.3 H. The quantity required must be coordinated with the Engineer.

2.2.2 Contractor Provided Equipment

A. Contractor Provided Equipment for Traffic Signal Control Cabinets

Deliver Contractor provided equipment for integration into the State provided traffic control signal cabinet at least 30 business days in advance of needing the traffic control signal cabinet on the project to the following address:

MnDOT Electrical Services Section (ESS)
6000 Minnehaha Avenue
St. Paul, MN. 55111- 4014.

To ensure integration into the correct signal cabinet, before delivery to ESS label the Contractor provided equipment packaging with the following:

(1) Assigned Traffic Engineering (TE) Number,
(2) State Project Number,
(3) Contractor name, and
(4) Contact name and phone number.

Notify ESS at least 3 business days in advance before delivering Contractor provided equipment by contacting the following in the order listed until notification has been received:

(1) Electronic Maintenance Supervisor 651-366-5759,
(2) Stockroom 651-366-5720, or
(3) Transportation Program Supervisor 651-366-5753,

Have the TE Number on hand before calling ESS.

B. Rodent Intrusion Barrier

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Rodent intrusion barrier listed on MnDOT's Approved Products List for Signals may be used instead of stainless steel woven wire cloth specified in 2565.2.DD for traffic signal pole transformer bases Standard Plate No. 8121.

C. Arc -Flash Hazard Warning Labels

1. Provide 4 in H x 6 in W vinyl or polyester labels meeting the following:

1.1. White background,
1.2. Orange background behind the WARNING text,
1.3. Black text,
1.4. Self-adhesive,
1.5. Machine printed letters and numbers, and
1.6. Water-resistant.

2. Figure 1 is for information and reference only.

Figure 1: Arc-Flash Warning Label – Category 1

Include the paragraphs below only if the signal system is going to be painted. Add required paint color

All RED text must be removed from the special provisions prior to the special provisions being submitted for project letting.

D. Painting Traffic Control Signal Pedestals, Shafts & Poles and Mast Arms

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Paint metal structures and metal component parts at the factory in accordance with all applicable provisions of MnDOT 2478 and 3532.

3. Provide painted steel traffic control signal pedestal shafts and painted pedestal bases at the locations shown on the Plans in accordance with the applicable provisions of MnDOT Standard Plate No. 8112, 8122, 8129, MnDOT 3832, and the following requirements:

Add paint color here.

All RED text must be removed from the special provisions prior to the special provisions being submitted for project letting.

4. Provide painted traffic control signal poles and mast arms at the locations shown on the Plans in accordance with the applicable provisions of MnDOT Standard Plate No. 8121, 8123, 8133, and the following requirements:

Add paint color here.

All RED text must be removed from the special provisions prior to the special provisions being submitted for project letting.

The following language needs to be included if you are designing a signal system with flashing yellow arrow (FYA) with a combined thru and left turn lane. An additional application would be HAWK Pedestrian type ped crossing.

All RED text must be removed from the special provisions prior to the special provisions being submitted for project letting.

E. Cluster Head Adaptor

Provide Cluster head adaptors at locations as shown on the Plan.

Use MnDOT approved cluster head adaptors listed on MnDOT's Approved/Qualified Products List for Signals:

http://www.dot.state.mn.us/products/index.html

The following language needs to be included if you are designing a signal system with flashing yellow arrow (FYA) with a combined thru and left turn lane. This indication is only intended to be used in this application.

All RED text must be removed from the special provisions prior to the special provisions being submitted for project letting.

F. Bi Modal Green and Yellow Arrow Signal Indications

Provide green and yellow bi-modal signal indications at locations as shown on the Plan.

Use MnDOT approved bi-modal signal indications listed on MnDOT's Approved/Qualified Products List for Signals:

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http://www.dot.state.mn.us/products/index.html

G. Accessible Pedestrian Signals (APS) – (Audible Pedestrian Push Button Units and Associated Traffic Control Signal Cabinet Equipment)

Provide Accessible Pedestrian Signals in accordance with MnDOT 3833 and as follows:

The APS push button manufacturer must provide the required voice messages in each button as defined below. Additionally the APS manufacturer must supply backup copies of the voice messages to the Electrical Services Section on one of the following media types:
Compact Disk
USB flash drive.

Deliver all Accessible Pedestrian Signals (APS) components, except push button units, to MnDOT's Electrical Services Section for installation into the Department provided traffic control signal cabinet. Deliver the components to be installed in the traffic control signal cabinet to the above location at least 30 normal business days in advance of when the department provided traffic control signal cabinet is required on the job site.

Present the order form below to the APS manufacturer so the appropriate Braille message is added to the pedestrian information sign and the correct voice messages are programmed in the pedestrian push buttons.

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The following order form must be filled out by the special provisions writer before inclusion in the final set of special provisions. The order form should be left as separate pages so they can be removed.

All RED text must be removed from the special provisions prior to the Special Provisions being submitted for project letting.

Accessible Pedestrian Signal (APS)
ORDER FORM
(Fill out one form per intersection)

Intersection:

System I.D. _____
T.E. No. _____ **Total Qty of Pedestrian Push Buttons**_____

Control Board: One needed for each intersection **Qty** 1

CCU: (Central Control Unit) One needed for each intersection **Qty** 1

CONFIG: (Configurator) One needed for each intersection when available **Qty** 1

Push Button and Sign Braille Information

Button	Arrow Direction R/L	Button	Street Name (Street Being Crossed)
PB2-1		PB2-1	
PB2-2		PB2-2	
PB2-3		PB2-3	
PB2-4		PB2-4	
PB4-1		PB4-1	
PB4-2		PB4-2	
PB4-3		PB4-3	
PB4-4		PB4-4	
PB6-1		PB6-1	
PB6-2		PB6-2	
PB6-3		PB6-3	
PB6-4		PB6-4	
PB8-1		PB8-1	
PB8-2		PB8-2	
PB8-3		PB8-3	
PB8-4		PB8-4	

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Custom Voice Message Details

Voice on Location and Walk Message(s) Please give phonetic pronunciation on difficult street names so that the message will be recorded correctly.

*Note that unless Street, Drive, Avenue etc…are absolutely necessary for intersection identification, it is recommended to not include them in the verbal message.

PB2-1

Wait Message:
Wait to Cross _____ (Street Being Crossed) **at** _____ (Intersecting Street)

Walk Message:
_____ (Street Being Crossed) **Walk sign is on to cross** _____ (Street Being Crossed)

PB2-2

Wait Message:
Wait to Cross _____ (Street Being Crossed) **at** _____ (Intersecting Street)

Walk Message:
_____ (Street Being Crossed) **Walk sign is on to cross** _____ (Street Being Crossed)

PB2-3

Wait Message:
Wait to Cross _____ **at** _____

HANDOUT

HANDOUT

HANDOUT

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(Street Being Crossed) (Intersecting Street)

Walk Message:

_____ **Walk sign is on to cross** _____

(Street Being Crossed) (Street Being Crossed)

PB2-4

Wait Message:

Wait to Cross _____ **at** _____

(Street Being Crossed) (Intersecting Street)

Walk Message:

_____ **Walk sign is on to cross** _____

(Street Being Crossed) (Street Being Crossed)

PB4-1

Wait Message:

Wait to Cross _____ **at** _____

(Street Being Crossed) (Intersecting Street)

Walk Message:

_____ **Walk sign is on to cross** _____

(Street Being Crossed) (Street Being Crossed)

PB4-2

Wait Message:

Wait to Cross _____ **at** _____

(Street Being Crossed) (Intersecting Street)

Walk Message:

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_____ **Walk sign is on to cross** _____

(Street Being Crossed) (Street Being Crossed)

PB4-3

Wait Message:

Wait to Cross _____ **at** _____

(Street Being Crossed) (Intersecting Street)

Walk Message:

_____ **Walk sign is on to cross** _____

(Street Being Crossed) (Street Being Crossed)

PB4-4

Wait Message:

Wait to Cross _____ **at** _____

(Street Being Crossed) (Intersecting Street)

Walk Message:

_____ **Walk sign is on to cross** _____

(Street Being Crossed) (Street Being Crossed)

PB6-1

Wait Message:

Wait to Cross _____ **at** _____

(Street Being Crossed) (Intersecting Street)

Walk Message:

_____ **Walk sign is on to cross** _____

(Street Being Crossed) (Street Being Crossed)

PB6-2

Wait Message:

Wait to Cross _____ **at** _____

(Street Being Crossed) (Intersecting Street)

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Walk Message:

	Walk sign is on to cross	
(Street Being Crossed)		(Street Being Crossed)

PB6-3

Wait Message:

Wait to Cross	**at**	
(Street Being Crossed)		(Intersecting Street)

Walk Message:

	Walk sign is on to cross	
(Street Being Crossed)		(Street Being Crossed)

PB6-4

Wait Message:

Wait to Cross	**at**	
(Street Being Crossed)		(Intersecting Street)

Walk Message:

	Walk sign is on to cross	
(Street Being Crossed)		(Street Being Crossed)

PB8-1

Wait Message:

Wait to Cross	**at**	
(Street Being Crossed)		(Intersecting Street)

Walk Message:

	Walk sign is on to cross	
(Street Being Crossed)		(Street Being Crossed)

PB8-2

Wait Message:

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Wait to Cross		**at**	
	(Street Being Crossed)		(Intersecting Street)

Walk Message:

	Walk sign is on to cross	
(Street Being Crossed)		(Street Being Crossed)

PB8-3

Wait Message:

Wait to Cross		**at**	
	(Street Being Crossed)		(Intersecting Street)

Walk Message:

	Walk sign is on to cross	
(Street Being Crossed)		(Street Being Crossed)

PB8-4

Wait Message:

Wait to Cross		**at**	
	(Street Being Crossed)		(Intersecting Street)

Walk Message:

	Walk sign is on to cross	
(Street Being Crossed)		(Street Being Crossed)

Walk Interval Messages

Model message for the walk interval, applicable to most intersections.

- "Howard. Walk sign is on to cross Howard."

Pushbutton Information Messages

Model message for pushbutton intersection identification information.

- "Wait to cross Howard at Grand."

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H. Equipment Pad

Provide an equipment pad as detailed in the Plans and specified in these Special Provisions.

The equipment pad contains the following:

1. Traffic control signal cabinet and control equipment.

   Traffic control signal cabinet, anchor rods, nuts and washers and associated internal control equipment to be provided by the Department and installed by the Contractor.

2. Signal Service Cabinet.

   Signal service cabinet Type SSB to be provided and installed by the Contractor. SSB cabinets will be supplied from the manufacturer with anchor rods, nuts and washers used for attaching the service cabinet to the equipment pad.

I. Blank

J. Signal Service Cabinet, Type SSB (with Battery Back-up Equipment)

Use this paragraph if the District wants a full blown SSB cabinet with a battery backup system. The spec writer needs to use this or the other paragraph for an SSB Service cabinet.

All RED text must be removed from the special provisions prior to the special provisions being submitted for project letting.

Provide a signal service cabinet in accordance with MnDOT 3837.2A.7 and as follows:

Type SSB with battery back-up equipment that includes an inverter, batteries, bypass switch, and external strobe.

K. Signal Service Cabinet, Type SSB (without Battery Back-up Equipment)

Use this paragraph if the District wants a SSB cabinet without batteries, inverter and bypass switch. The SSB service cabinet will not have any back up capabilities. The backup system can be added at a later date to the standard SSB cabinet that would be provided using this paragraph. The spec writer needs to

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use this or the other paragraph for an SSB Service cabinet.

All RED text must be removed from the special provisions prior to the special provisions being submitted for project letting.

Provide a signal service cabinet in accordance with MnDOT 3837.2A.7 and as follows:

Type SSB service cabinet without battery backup equipment. Do not provide an inverter, batteries, bypass switch or external strobe.

L. Advance Warning Flashers (AWF)

Traffic control signal pedestal shafts and pedestal bases must be in accordance with the applicable provisions of MnDOT Standard Plate 8122, 8129, MnDOT 2565, 3832, and as detailed in the Plan.

Provide all materials and electrical equipment to provide four (4) complete operating advance warning flashers (Signal Base No.'s __, __, __, and __) at the locations shown on the Plans in accordance with the "ADVANCE WARNING FLASHER DETAILS" in the Plans and with the following:

1. Traffic control signal pedestals in accordance it 3832.

2. Flashing Beacon Assemblies as follows:

   (2.1) 12 inch, polycarbonate vehicle signal heads for flashing beacon assemblies in accordance with 3834.

   (2.2) 12 inch "Yellow" signal indications in accordance with MnDOT 3834 and as follows:

   (2.3) Affix to the back of each "yellow" flasher indication a permanent label indicating the date of installation in accordance with 2565.3L.6 and to the satisfaction of the Engineer.

   (2.4) Each flashing beacon assembly must include a cut away visor and background shield as indicated on the detail in the Plan.

   (2.5) Attach flasher beacons as detailed in the Plans to the satisfaction of the Engineer.

3. Flashing Beacon Assembly Bracketing

   Provide aluminum flashing beacon assembly bracketing with anodic coating as per MIL-

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A-8625C for Type II, Class I Coating.

4. Wiring at Each Advance Warning Flasher:

   Provide a 4/c 14 AWG signal control cable in accordance MnDOT 3815.2 between the pole base connector in the pedestal base and each flashing beacon atop the advance warning flasher assembly.

5. Advance Warning Flasher Signs:

   Provide and install W3-X4 (PREPARE TO STOP WHEN FLASHING) signs in accordance with 2564.

   Mount each sign as detailed in the Plan to the satisfaction of the Engineer.

SS-3. CONSTRUCTION REQUIREMENTS

A. Installation of Department Provided Materials

Install the Department provided traffic control signal cabinet each complete with actuated controller unit and all required traffic control signal equipment.
Provide and install all additional materials and electrical equipment for a complete operating traffic control signal cabinet installation (which includes, but is not limited to:

1. A cabinet concrete foundation as part of the equipment pad concrete foundation using Department provided anchor rods, nuts, and washers.
2. Bonding and grounding materials and connections.
3. Make all field conductor connections in each traffic control signal cabinet as directed by the Engineer to make each traffic control signal system fully operational.

The following paragraph needs to be modified to give contractor specific location to deliver the pallet back to MnDOT.

All RED text must be removed from the special provisions prior to the Special Provisions being submitted for project letting.

Protect the Department provided cabinet pallet from damage and return the pallet to MnDOT Central Electrical Inventory Center at the address specified herein, or the District Headquarters.

B. Pick Up Department Provided Materials

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Pick up materials and electrical equipment described in (A) above at MnDOT's Electrical Services Section, 6000 Minnehaha Avenue, St. Paul, MN. 55111- 4014. Follow these requirements:

1. Request from MnDOT's Electrical Services Section the materials and electrical equipment listed in (A) above.
2. Direct the Electrical Services Section to the T.E. Request No. _____.
3. Request Department provided materials at least 30 business days in advance of needing the material on the project.
4. Notify MnDOT's Electrical Services Section at least 3 business days in advance of intention to pick up materials and electrical equipment.
   Contact:
   (1) Electronic Maintenance Supervisor 651-366-5759,
   (2) Stockroom 651-366-5720, or
   (3) Transportation Program Supervisor 651-366-5753,
5. Pick up the Department provided materials and electrical equipment at the above specified location and transport them to the job site.
6. Secure each cabinet in an upright position when transporting to the job site. Ensure that each cabinet being transported will not tip and be damaged.
7. Notify the Engineer in advance of contacting MnDOT's Electrical Services Section.

C. Rodent Intrusion Barrier

Install rodent intrusion barrier in accordance with 2545.3W.

Rodent intrusion barrier listed on MnDOT's Approved Products List may be installed instead of stainless steel woven wire cloth as specified in 2545.3.W for traffic signal pole transformer bases Standard Plate No. 8121.

Install the MnDOT APL barrier in accordance with the manufacturer's installation instructions. Fill gaps between the barrier and base plate, and between the barrier and the foundation with 100% silicone sealant.

D. Arc-Flash Hazard Warning Labeling

1. Calculate available fault current in accordance with 2545.3X and 2565.3 CC.
2. Establish available fault current and apply the appropriate label as follows.
3. Use the current edition of NFPA 70E "Standard for Electrical Safety in the Workplace" to determine the required PPE category and personal protective equipment.
4. If the available fault current is ≤ 25,000 amps then provide a label with the

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following information shown in Example 1.

Example 1

Warning
Arc Flash Hazard
Appropriate PPE Required
Arc Flash Boundary **19 Inches**
Arc Flash PPE Category **1**
Working Distance **18 Inches**
Arc Flash Personal Protection Equipment (PPE)
List required clothing, **Min Arc Rating of 4 cal/cm²**, and protective equipment in accordance with the PPE Table from the current edition of NFPA 70E Standard for Electrical Safety in the Workplace
Equipment ID

5. If the available fault current is > 25,000 amps:

5.1. Determine PPE requirements in accordance with the current edition of NFPA 70E Standard for Electrical Safety in the Workplace, and

5.2. Provide a label with the following information shown in Example 2. Fill in the **____ (blank)** with the required arc-flash PPE category and arc-flash boundary distance.

Example 2

Warning
Arc Flash Hazard
Appropriate PPE Required
Arc Flash Boundary **___Feet_**
Arc Flash PPE Category **_____**
Working Distance **18 Inches**
Arc Flash Personal Protection Equipment (PPE)
List required clothing, **Min Arc Rating of ___ cal/cm²**, and protective equipment in accordance with the PPE Table from the current edition of NFPA 70E Standard for Electrical Safety in the Workplace
Equipment ID

6. Install labels on the front of the dead front door of the electric service cabinet at eye level.

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The following Section should only be included in projects when the contractor is going to be required to do excavation work.

All Red text must be removed from the special provisions prior to the special provisions being submitted for project letting.

E. Maintenance of Existing Electrical Systems

Maintain and keep in operation new and existing electrical systems in accordance with 2565.3B and as follows:

The Contractor is responsible for locating all underground facilities of existing traffic control signal systems including temporary, and newly constructed signal systems within the limits of the construction project, for the duration of the construction project in accordance with the applicable provisions of MnDOT 1514 and in accordance with Minnesota State Statute 216D.

The responsibility for locating underground traffic control signal system facilities shall be transferred to the Contractor on the project start date as shown on the proposal.

MnDOT's locating group will provide an initial locate of the underground traffic control signal system facilities within the project limits at the request of the Contractor at the start of the project. The request for the initial locate must be submitted to MnDOT's Locating Office a minimum of 4 business days prior to the project start date.

Locate requests that are within the construction project limits will continue to be received by MnDOT's Locating Office. These locate tickets will be forwarded to the Contractor's representative responsible for coordinating locate requests within the projects limits. The locate tickets will be forwarded via e mail or fax. Confirmation of receipt of the locate ticket must be sent by the Contractors representative back to MnDOT's locating office within 2 hours of MnDOT's sending the Contractor's representative the locate request.

The Contractor responsible for locating all underground traffic control signal system facilities will repair any damage as the result of improperly located or unmarked underground traffic control signal system facilities within the project limits.

The repair of the damaged underground traffic control signal system facilities must be in accordance with 2545.3A, 2565.3B and in accordance with RTMC design and construction requirements all to the satisfaction of the Engineer. This work is considered incidental.

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It is the Contractor's responsibility to notify MnDOT's Locating Office to provide contact information and establish the contractor has assumed responsibility for locating MnDOT's underground traffic control signal system facilities within the project limits. The form below shall be filled out by the Contractor's representative and provided to the Engineer at the pre-construction meeting, a copy of and the completed form should be sent to the following:

Electrical Services Dispatch
Phone: (651)366-5750
Fax: (651)366-5742
E mail: ElectricalServicesDispatch@state.mn.us
6000 Minnehaha Ave. St. Paul, MN 55111-4014

and

Locating Supervisor
Phone: (651)755-9061
Fax: (651)366-5742
E mail: eric.klute@state.mn.us
6000 Minnehaha Ave. St. Paul, MN 55111-4014

(The following Section should be filled out by the specification writer to direct the contractor and project engineer to the correct person in the District.

All Red text must be removed from the special provisions prior to the special provisions being submitted for project letting.

MnDOT District Signal Operations
Name:
Phone:
Fax:
E mail:
Address:

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(The following Section should be left on its own page so the contractor can remove it and use the blank page)

All Red text must be removed from the special provisions prior to the special provisions being submitted for project letting.

Locating Responsibility Form

Job S.P. Number _____

Job Type _____

Start Date _____

End Date _____

T.H. _____

Location _____

Lighting/ Signal Inspector _____

Contractor _____

Contractor (24 Hour Contact) _____

Project Manager _____

Phone Number _____

Fax Number _____

Email _____

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Electrician _____

Phone Number _____

Locator Area _____

Project Engineer _____

Phone Number _____

Chief Inspector _____

Phone Number _____

Weekly Meeting _____

Until final written acceptance of the project by the Engineer (MnDOT 1716) this work is considered incidental.

During any periods of authorized work suspension, the contractor is responsible for maintenance of the existing, temporary, and newly constructed traffic control signal systems.

Provide to the Department contact information with the names and telephone numbers for 24 hours a day, 7 days a week maintenance as defined above.

Include the verbiage below if the traffic control signal will not have an Emergency Vehicle Preemption system installed. State law requires all traffic control signals to be pre wired for EVP. https://www.revisor.mn.gov/statutes/?id=169.06

The plan should include the 3/C14 AWG Signal Control Cable and the 3/C20 AWG EVP Detector Cable on the wiring diagram. These conductors should be pulled from the signal cabinet to the EVP round outlet box

All Red text must be removed from the special provisions prior to the special provisions being submitted for project letting.

F. Wiring for Future Emergency Vehicle Preemption

Provide Signal Control Cable (3/C14 AWG) and Emergency Vehicle Pre-emption (EVP) Detector Cable (3/C 20 AWG) in accordance with 2565.3J and as detailed in the Plans.

"2018 SAMPLE" TRAFFIC CONTROL SIGNAL SYSTEM SPECIAL PROVISIONS (November 16, 2017)

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Provide an EVP Round Outlet Box in accordance with 3814.2D.

Install signal control cable and EVP detector cable from the traffic control signal cabinet to the EVP round outlet box mounted on the mast arm.

G. Compliance with NEC Article 110. 24

Provide fault current calculations in accordance with 2565.3 CC and as follows:

1. Electric Service Information Form

Fill out the following electric service information form shown below for traffic control signal systems.

Provide to the Engineer, prior to final acceptance of the project, four (4) copies of the electric service information form for traffic control signal systems and the Engineer will distribute the copies as follows:

1. MnDOT Electrical Services Section.
2. MnDOT Traffic Electrical Systems Engineer.
3. MnDOT District Traffic Engineer.
4. City of _____ or County of_____.

The Contractor provided "electrical service information form for traffic control signal systems" and available fault current calculations and labeling are considered incidental work.

(The following form should be left on its own page so it can be removed from the special provisions and used by the contractor) See the next page of this document

All Red text must be removed from the special provisions prior to the special provisions being submitted for project letting.

HANDOUT

HANDOUT

"2018 SAMPLE" TRAFFIC CONTROL SIGNAL SYSTEM SPECIAL PROVISIONS (November 16, 2017)

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Electric Service Information Form For Traffic Control Signal Systems

Project Number: ____________ Contractor: ____________

Date: ____________

MN/DOT Signal System ID	Intersection	Meter Address	Transformer Primary Fuse Size and Type	Electric Utility Transformer Size in KVA	Transformer Internal Impedance Z in Percent	Transformer Secondary Voltage Line to Line and Line to Neutral	Size of Conductors In American Wire Gauge (AWG)	Length of conductors in feet from transformer connection to meter socket connection.			Calculated Available Fault Current at the line Side of the Meter Socket	Service Cabinet Main Circuit Breaker Size in AMPS
								L1 =	L2 =	Neutral		
								L1 =	L2 =	Neutral		
								L1 =	L2 =	Neutral		
								L1 =	L2 =	Neutral		
								L1 =	L2 =	Neutral		

NEC Article 110.24

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24-SS

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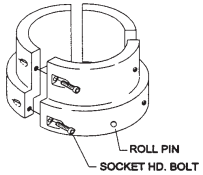
H. Pedestal Reinforcing Collar (Wind Collar) Installation

Where the pedestal reinforcing collar is utilized, clamp each reinforcing collar around the top of the pedestal base by using two (2) 5/16" Socket Head Bolts per section (see figure below).

Each section must have a 5/16" pilot hole for drilling into base. Drive a 5/16" x ¾" Roll Pin through the collar into the base (flush to allow ¼" penetration into the base) to prevent the pedestal shaft from turning in the pedestal base.



(The following language is to be used for required warning stickers on the backside of sign panels being installed on the signal system project. The Specification Writer must include the appropriate District contact person and phone number to the following paragraph).

All Red text must be removed from the special provisions prior to the special provisions being submitted for project letting.

I. Blank

J. Sign Panel Warning Stickers

Install Department furnished warning stickers on new sign panels in accordance with MnDOT 2564.3H.

Give 30 business days advance notice to_____ at ___-___-____ prior to picking up the Department furnished warning stickers.

K. Removals

When directed by the Engineer, remove and salvage, or dispose of all items of the existing traffic

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control signal system in accordance with the applicable provisions of MnDOT 2565.3Y; the applicable provisions of MnDOT 2104; and the following:

1. Abandon underground conduit in place, unless otherwise directed by the Engineer.

--- or ---

Except under roadway surfaces, remove and dispose of all underground conduit as specified herein.
Under roadway surfaces, abandon conduit in place, unless otherwise directed by the Engineer.

2. After the traffic control signal cabinet and control equipment is de-energized and power conductors disconnected, prevent damage to the cabinet and control equipment as follows:

   (2.1) Unplug and remove all removable control equipment (i.e., controller unit, detector amplifier units, conflict monitor, load switches, etc.) from the cabinet. Suitably pack the control equipment removed from the cabinet to prevent damage to the equipment during transportation.

   (2.2) Coil and group together connecting harnesses for the equipment and secured to a shelf in the cabinet. Tape, wire, or tie wrap the harnesses by a method that prevents the harnesses from being pinched in the door when the door is closed or from dropping below the bottom of the cabinet when it is lifted off the foundation.

   (2.3) Secure the cabinet in an upright position at all times (removing from foundation, transporting, loading, and unloading) to insure that the cabinet will not tip and be damaged.

3. After the battery backup service cabinet is de-energized and power conductors disconnected, remove the batteries and uninterrupted power supply (UPS) from the cabinet for shipping. Prevent damage to the cabinet, UPS and batteries for shipment to MnDOT as defined below.

   Disassemble the salvaged traffic control signal cabinet, battery backup cabinet and control equipment as specified herein and deliver to the Department at MnDOT's Central Electrical Inventory Center at the location specified elsewhere in these Special Provisions. Notify MnDOT's Central Electrical Inventory Center at least 3 business days in advance of the time the Contractor intends to deliver the salvaged materials.

   Notify the Engineer in advance of contacting MnDOT's Central Electrical Inventory Center.

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Obtain a salvaged material receipt from MnDOT's Central Electrical Inventory Center indicating that MnDOT has received the salvaged material.

Provide to the project Engineer a copy of this receipt for the permanent project records.

4. Removed entirely and disposed of outside the Right-of-Way all items not salvaged, in any manner that the Contractor may elect, subject to the provisions of MnDOT 2104.3, and as follows:

(4.1) Remove and dispose of the mast arm pole standards and pedestal shafts as specified herein.

(4.2) After removal, disassemble and cut-up the mast arm pole standards (transformer base, pole shafts, mast arms, and luminaire extensions), or other method that renders the mast arm pole standards unusable, to the satisfaction of Engineer. After the mast arm pole standards have been prepared for disposal, dispose of the mast arm pole standards and traffic control signal pedestals as follows:

a) The mast arm pole standards and the traffic control signal pedestals (pedestal shafts and pedestal bases) may have lead-based paint. If this is the case, the Contractor is responsible for the proper handling, transportation, and disposal of the mast arm pole standards and traffic control signal pedestals as hazardous waste and the handling, transportation, and disposal of these items in accordance with Occupational Safety & Health Administration (OSHA) and the Minnesota Pollution Control Agency (MPCA) regulations.

b) The Contractor certifies that he or she is familiar with, and will comply with, the applicable requirements in OSHA 29 CFR 1926.62 and Minnesota Rules Chapter 5206, 7025, 7035, 7045 relating to disposal and/or the removal of these lead painted mast arm pole standards and traffic control signal pedestals as hazardous waste.

c) Provide to the Engineer a completed "Contractor Certification of Disposal" form included elsewhere in these Special Provisions.

d) Backfill and compact all resulting excavation with like in kind material to approximately the same density as the adjoining ground. Replace in kind any roadway surfacing (concrete pavement, bituminous surface, or gravel surface, including underlying base courses), sidewalks, curb and gutters, sod, etc., removed by the construction operations at no expense to the Department.

All removals of materials of the existing signal system and salvaging as required, the disposal of non-salvable materials, and backfilling, all in accordance with the foregoing, is considered incidental

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work.

SS-4. MEASUREMENTS AND PAYMENTS

Ensure Division S Special Provisions "As-Builts" are included in the Division S Special Provisions. This would include the pay item 2011.601.

2011.601/01000	AS BUILT	AS BUILT	LS	LUMP SUM	2018

The District needs to include the verbiage below to trigger installation of Divisions S Special Provisions.

Add the pay item as shown above to your pay item list.

All Red text must be removed from the special provisions prior to the special provisions being submitted for project letting.

A. As Built Drawings and GPS Coordinates

As Built drawings and GPS coordinates in accordance with Division S Special Provisions "AS-Builts" including Pay Item No. 2011.601 (AS BUILT).

B. TRAFFIC CONTROL SIGNAL SYSTEM

Removing and salvaging, or disposing of the existing traffic control signal system; providing and installing materials and electrical equipment; and installing Department provided materials as specified herein, all to provide a complete operating new full-traffic-actuated traffic control signal system at the intersection of _____ and _____in _____, _____ County as contained in these Special Provisions and in the Plans will be measured as an integral unit and paid for as specified in MnDOT 2565.4 and MnDOT 2565.5 respectively for Item No. 2565.516 (TRAFFIC CONTROL SIGNAL SYSTEM).

Only use the paragraph below when the District is requiring materials to be salvaged from a project.

All Red text must be removed from the special provisions prior to the special provisions being submitted for project letting.

C. HAUL SALVAGED MATERIAL

All delivery of salvaged materials to the Department at the location specified herein is paid for under Item No. 2104.601 (HAUL SALVAGED MATERIAL) at the contract LUMP SUM price and is considered payment in full for all costs relative to hauling the materials to, and depositing the materials, at the location specified herein.

Contractor Certification of Disposal

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Project No.:_____ **Location**: _____

We, _____, hereby certify that the mast arm pole standards
(Name of Contractor)
were rendered unusable, and the mast arm pole standards, and if applicable, pedestal shafts and bases were removed, transported, and disposed of in accordance with all requirements of the Minnesota Pollution Control Agency (MPCA) and the Occupational Safety & Health Administration (OSHA) for the removal, transporting, and disposal of hazardous waste.

_____ _____
SIGNATURE DATE

After signed and dated, the Contractor must submit this form to MnDOT's project Engineer. The Contractor must also submit to the Engineer a copy of the "Tipping Receipt" that the Contractor receives from the scrap yard or recycler.

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SS-5. (2565) EMERGENCY VEHICLE PREEMPTION (EVP) SYSTEM

This work consists of providing and installing emergency vehicle preemption (EVP) system at the intersection of _____ (_____) and _____ in _____, _____ County in accordance with the applicable provisions of MnDOT 2565; with the Plans; and as follows:

SS-5.1 GENERAL

(None)

SS-5.2 MATERIALS

Provide Emergency Vehicle Preemption (EVP) equipment in accordance with MnDOT 2565 and 3814. Phase selectors (or other EVP equipment to be installed in the traffic control signal cabinet) will be installed in the Department furnished cabinet by MnDOT personnel.

Deliver all EVP phase selectors or other required EVP equipment to be installed in the traffic control signal cabinet to the Department at MnDOT's Electrical Services Section for installation into the Department furnished traffic control signal cabinet. Provide the equipment at least 30 business days in advance of when the Department furnished traffic control signal cabinet is required on the job site.

SS-5.3 CONSTRUCTION REQUIREMENTS

Place in accordance with 2565.3.

SS-5.4 MEASUREMENT AND PAYMENT

Providing and installing emergency vehicle preemption (EVP) system at the intersection of T.H. ___ and _____ in _____, _____ County as specified herein is measured as an integral unit complete in place and operating and is paid for under Item No. 2565.501 [EMERGENCY VEHICLE PREEMPTION SYSTEM] at the Contract price per LUMP SUM, which price is compensation in full for all costs incidental thereto.

SS-6. (2565) TRAFFIC CONTROL INTERCONNECT

This work consists of providing and installing conduit, handholes, interconnect cable, and system loop detectors, for traffic control interconnect on T.H. ___, at the locations shown on the Plans, all in accordance with the applicable provisions of MnDOT 2565; with the current edition of the National

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"2018 SAMPLE" TRAFFIC CONTROL SIGNAL SYSTEM SPECIAL PROVISIONS (November 16, 2017)

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Electrical Code; with the Plans; and as follows:

SS-6.1 GENERAL

A. As part of the traffic control interconnect, the Department will provide the master controller unit when required and all required master control equipment as part of the traffic control signal cabinet at _____ to operate the interconnected coordinated traffic control signal systems on T.H. ____ between ____ Street and ____ Street.

Or

The master controller unit and all required master control equipment to operate the interconnected coordinated traffic control signal systems on T.H. ___ is in place and located at the intersection of T.H. ___ and _____.

B. MnDOT personnel will make all interconnect cable connections in each intersection traffic control signal cabinet to make the interconnected coordinated portion of the traffic control signal system operational.

SS-6.2 MATERIALS

Interconnect Cable

Provide interconnect cable (___ PAIR 19 AWG shown on the Plans) in accordance with MnDOT 3815.2C.6b.

SS-6.3 CONSTRUCTION REQUIREMENTS

Place interconnect cable in accordance with MnDOT 2565.3J2.

SS-6.4 MEASUREMENT AND PAYMENT

Providing and installing conduit, handholes, interconnect cable, and system loop detectors for traffic control interconnection on ____, at the locations shown on the Plans, as contained in these Special Provisions and in the Plans will be measured as an integral unit complete in place and operating and will be paid for under Item No. 2565.501 (TRAFFIC CONTROL INTERCONNECT) at the Contract price per LUMP SUM, which price will be compensation in full for all costs incidental thereto.

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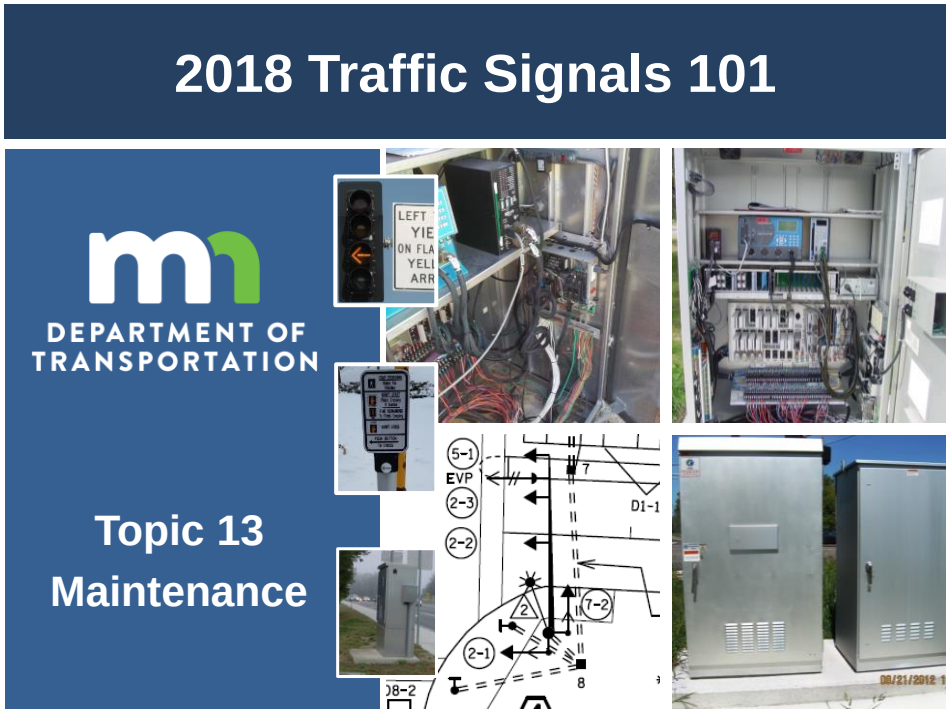
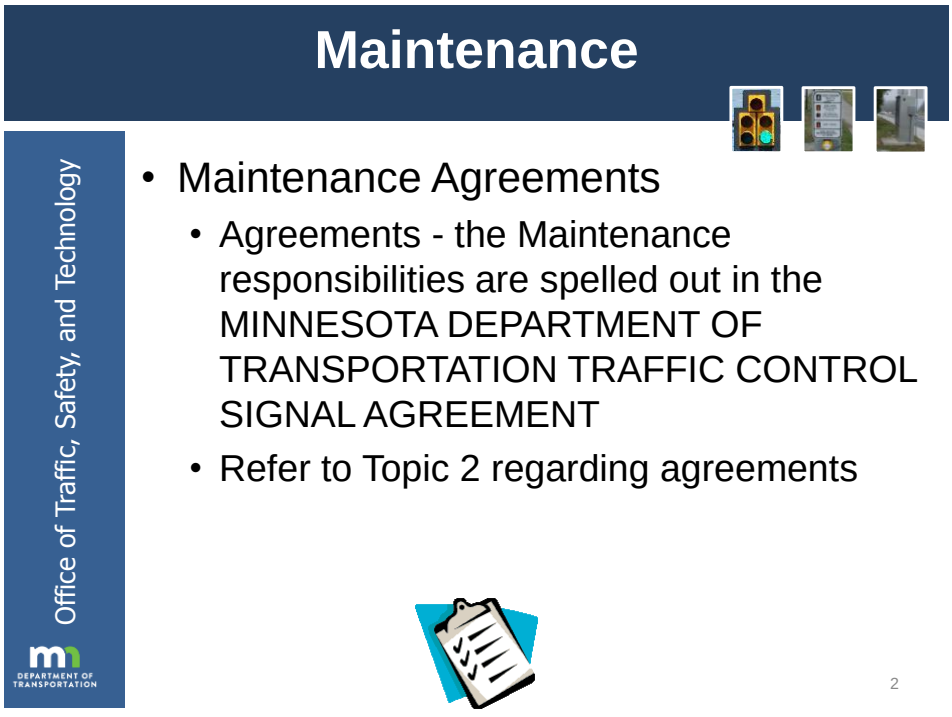
TOPIC 13: MAINTENANCE



In this topic you will be introduced to:

- Maintenance Agreements
- Traffic Signal Maintenance Categories



The agreement will have a number upon which other documents may refer to. The number will be in effect until another agreement is written, in which it will state that the new number super cedes and terminates the old agreement number.

Maintenance

Office of Traffic, Safety, and Technology

- Maintenance Agreements
  - Power cost provider is specified in the agreement
  - The maintenance responsibilities will be outlined in this agreement
  - Maintenance is divided into two categories for entity responsibilities:
    - Minor Maintenance
    - Major Maintenance

3

A quick and easy reference is the **signal responsibility list**, which is a report in the facility management system. This list can be generated by the District Traffic Offices or requested by the Electrical Services Section (ESS) and they will generate a list.

The list contains an index that shows the responsibility types, the system types with abbreviations and has a format that makes the responsibility easily recognizable.

The handout at the back of this topic shows a sample agreement, a sample responsibility list and code definitions.

Maintenance

Office of Traffic, Safety, and Technology

- Maintenance Agreements
  - Minor maintenance
    - Vehicle indication lights
    - Luminaire lamp replacement
    - Paint signals
  - Major Maintenance
    - Knockdowns
    - Loop replace/repair
    - Head replace

4

As previously noted, maintenance is divided into Minor Maintenance and Major Maintenance.

Maintenance

Office of Traffic, Safety, and Technology

- Traffic Signal Maintenance can be divided into four categories
  - **Response** Maintenance
  - **Preventative** Maintenance
  - **Operations** Maintenance
  - Design Modification

5

This slide shows the four categories of traffic signal maintenance.

Maintenance

Office of Traffic, Safety, and Technology

- Maintenance Responsibilities
  - **Response Maintenance**
    - Knockdowns
    - Heads turned/indications out
    - Loop failure
    - Operations complaint

6

Response Maintenance involves procedures that are undertaken when traffic signal and control equipment fails, either fully or partially.

Maintenance

Office of Traffic, Safety, and Technology

- Maintenance Responsibilities
  - **Preventative Maintenance**
  - Performed by MnDOT Electrical Services Unit (ESU)
  - Performed every 12-24 months
    - Test MMU
    - Check indications
    - Check loops
    - Check pedestrian pushbuttons
    - Check controller and clock
    - Additional items

7

Preventative Maintenance practices involve inspecting, cleaning, and adjusting signals at regular intervals and replacing components as necessary.

Maintenance

Office of Traffic, Safety, and Technology

- Maintenance Responsibilities
  - **Operations Maintenance (check)**
  - Performed by MnDOT District Operations Staff
  - Performed every 6 - 12 months
    - Check operation
    - Check indications
    - Check loops
    - Check pedestrian pushbuttons
    - Check controller and clock
    - Clean cabinet and replace air filter(1/per year)

8

Operations Maintenance is as defined in this slide.

Maintenance

Office of Traffic, Safety, and Technology

- Maintenance Responsibilities
  - **Design Modification**
  - Performed on an as needed basis or as funding allows.

    Upgrading outdated equipment

    Replacing end of life hardware

    ADA upgrades

    Flashing yellow arrow retro fit

9

Design Modification involves changing the signal display, timing plans, or equipment to reflect changed traffic conditions.

Maintenance

Office of Traffic, Safety, and Technology

New Signals

District Operations Responsibilities

- District assures the timing and operation needed is programmed into the controller.
- All indications, loops, ped buttons, evp are checked to assure the signal is operating at 100% at turn on
- When a new signal is placed into operation, a log book must be put into the cabinet, along with field intersection layouts and cabinet prints.
- The pole base connector detail must be part of the log book or cabinet file.

10

The district operations responsibilities are described in this slide.

HANDOUT

SAMPLE AGREEMENT AND SAMPLE STATEWIDE RESPONSIBILITY LIST

SAMPLE AGREEMENT

MINNESOTA TRANSPORTATION DEPARTMENT

TRAFFIC CONTROL SIGNAL

AGREEMENT NO. 73845

BETWEEN

THE STATE OF MINNESOTA, DEPARTMENT OF TRANSPORTATION

AND

THE COUNTY OF ANOKA

AND

THE CITY OF LINO LAKES

TO

Install a new Traffic Control Signal with Street Lights, Emergency Vehicle Pre-emption and Signing on Trunk Highway No. 49 (Hodgson Road) - County State Aid Highway No. 10 (North Road) at Trunk Highway No. 49 (Lake Drive) - County State Aid Highway No. 23 (Lake Drive) in Lino Lakes, Anoka County, Minnesota.

S.P. 0204-12
S.A.P. 02-610-09 and 02-623-07

Prepared by Traffic Engineering

ESTIMATED AMOUNT RECEIVABLE		AMOUNT ENCUMBERED
Anoka County	$5,000.00	
City of Lino Lakes	$5,000.00	$68,580.00

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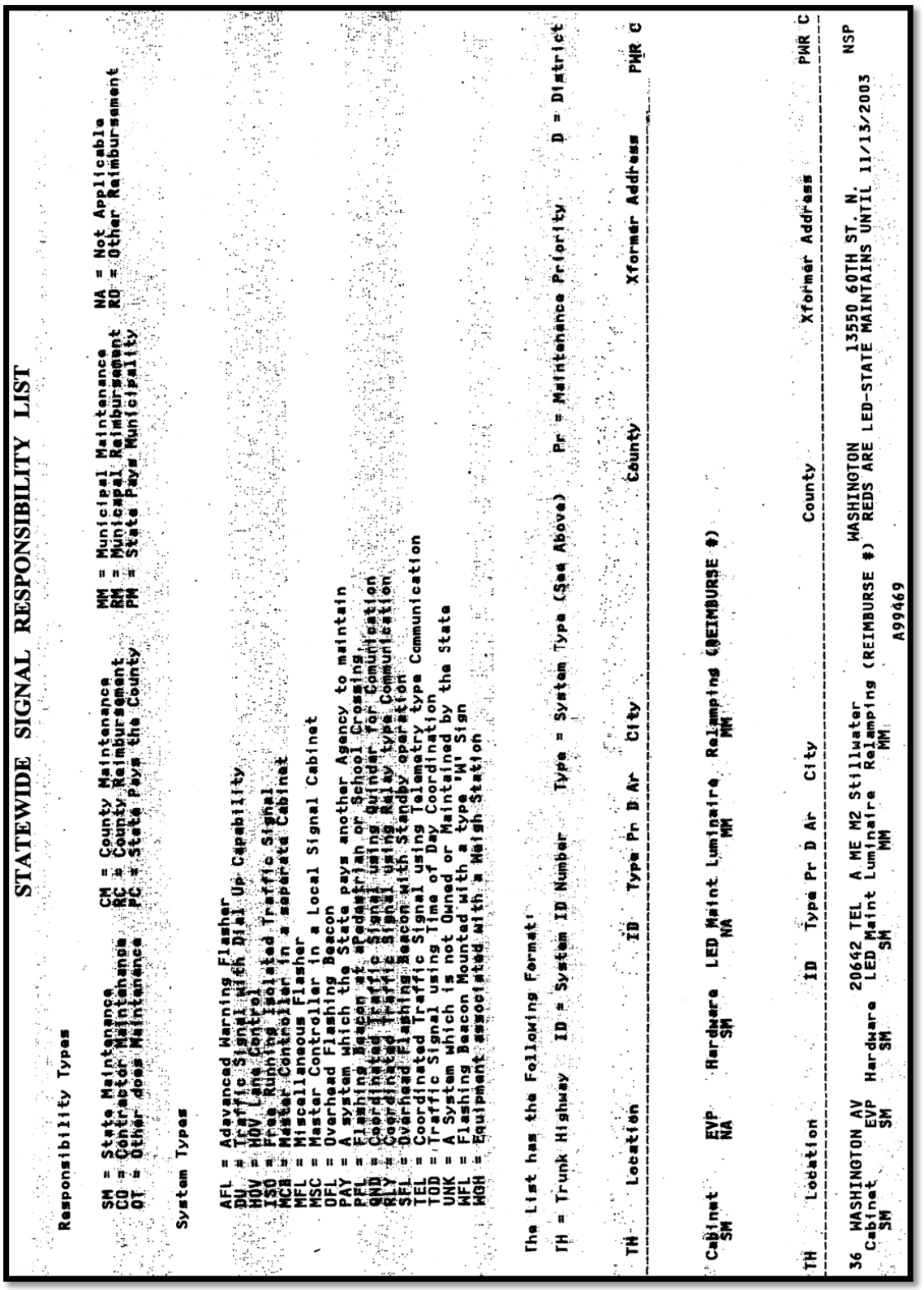
SAMPLE STATEWIDE RESPONSIBILITY LIST



STATEWIDE SIGNAL RESPONSIBILITY LIST

Responsibility Types

SM = State Maintenance
CO = Contractor Maintenance
OT = Other does Maintenance
CM = County Maintenance
RC = County Reimbursement
PC = State Pays the County
MM = Municipal Maintenance
RM = Municipal Reimbursement
PM = State Pays Municipality
NA = Not Applicable
RO = Other Reimbursement

System Types

AFL = Advanced Warning Flasher
DU = Traffic Signal with Dial Up Capability
HOV = HOV Lane Control
ISO = Free Running Isolated Traffic Signal
MCB = Master Controller in a separate Cabinet
MFL = Miscellaneous Flasher
MSC = Master Controller in a Local Signal Cabinet
OFL = Overhead Flashing Beacon
PAY = A system which the State pays another Agency to maintain
PFL = Flashing Beacon at a Pedestrian or School Crossing
RND = Coordinated Traffic Signal using Wunder for Communication
RLY = Coordinated Traffic Signal using Relay type Communication
SFL = Overhead Flashing Beacon with Standby operation
TEL = Coordinated Traffic Signal using Telemetry type Communication
TOD = Traffic Signal using Time of Day Coordination
UNK = A System which is not Owned or Maintained by the State
WFL = Flashing Beacon Mounted with a type 'W' Sign
WGH = Equipment associated with a Weigh Station

The List has the Following Format:

TH = Trunk Highway ID = System ID Number Type = System Type (See Above) Pr = Maintenance Priority D = District

TH	Location	ID	Type	Pr	D	Ar	City	County	Xformer Address	PWR C
Cabinet SM	EVP NA	Hardware SM	LED Maint Luminaire NA	Relamping (REIMBURSE #) MM						

TH	Location	ID	Type	Pr	D	Ar	City	County	Xformer Address	PWR C
36	WASHINGTON AV	20642	TEL	A	ME	M2	Stillwater	WASHINGTON	13550 60TH ST. N.	NSP
Cabinet SM	EVP SM	Hardware SM	LED Maint Luminaire SM	Relamping (REIMBURSE #) MM	REDS ARE LED-STATE MAINTAINS UNTIL 11/13/2003					
					A99469					

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- THE SIGNAL RESPONSIBILITY LIST HAS THE FOLLOWING HEADINGS:
  - **TH** = Trunk Highway ID number, the highway the signal is located on
  - **Location** = The cross street the signal is located on
  - **System** = System ID number Each signal system is assigned an ID number
  - **Type** = System Type outlined below
  - **Pr** = Maint. Priority Established to set the level in which a signal needs responding, A-B-C-D
  - **D** = District in which the signal is located or is responsible for its maintenance
  - **City** = City the signal is located in or is responsible for its maintenance
  - **County** = County the signal is located
  - **Xformer address** = The address the power company has for the location
    - This is important when reporting a power outage
  - **PWR C** = Power company which supplies power to the signal
  - **Cabinet** --- All equipment within and including cabinet
  - **EVP** --- Emergency vehicle pre-emption All associated equipment both in the cabinet and in the field
  - **Hardware** --- Any equipment in the field including the underground
  - **LED maint.** --- This is in order to encourage other entities to use light emitting diode signal heads, the State agreed to honor the factory warranty and replace any failed units for a specified time
  - Any new installations will not be on the list. In time this heading will disappear
  - **Luminaire** --- The luminaires (street lights) over the traffic signals
  - **Relamping** --- (Reimburse number) Replacing of the lamps in the signal heads
    - The reimbursable number is the number used to bill another entity for the work which was the responsibility of the entity
- Responsibility Types
  - **SM**= State Maintenance
  - **NA**= Not applicable meaning there isn't EVP in this intersection
  - **CM**= County Maintenance
  - **PC**= Pay County State pays County for any maintenance performed
  - **MM**= Municipal maintenance
  - **RM**= Reimbursable maintenance means State is reimbursed for any maintenance
- System Types
  - **ISO** = Free Running Isolated Traffic Signal
    - This would be a signal that operates independently of any other signal or system
  - **DU** = Traffic Signal with Dial Up Capability
    - A signal would be capable of being monitored with a computer and phone line from a remote location
  - **TEL** = Coordinated signal system using Telemetry type communication
    - This would be a signal operating within a system of other signals
    - There would be a series of intersections which would allow the passage of traffic with minimal stoppage
    - The signals have hardwire (interconnect) between them.
  - **AFL** = Advanced Warning Flasher
    - This is the flashers located ahead of the signal which warns motorists to prepare to stop
  - **OFL** = Overhead Flashing Beacon
    - A single or double signal head which flashes either yellow or red and is mounted overhead
  - **UNK** = A System which is not Owned or Maintained by the State
  - There are many other system types, which are indexed under that heading, the above are the most common

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