TRAFFIC CONTROL SIGNAL DESIGN MANUAL

June 2014

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INTRODUCTION

Traffic control signal technology has greatly expanded and has become a critical element in the safe and efficient movement of people and materials. Proper planning, design and installation of a traffic control signal system is critical to traffic operations and safety. Poorly planned and designed installations will, at best, impact the delay experienced and, at worst, create serious safety issues.

The purpose of this manual is to present the fundamental concepts and standard practices related to the design of traffic signals for the Minnesota Department of Transportation (MnDOT).

> *"In most cases the installation of a highway traffic signal will operate either to the advantage or disadvantage of the vehicles and persons controlled. A careful analysis of traffic operations and other factors at a large number of signalized and un-signalized intersections, coupled with the judgment of experienced engineers, have provided a series of warrants that define the minimum conditions under which signal installations may be justified. Consequently the selection and use of this control device should be preceded by a thorough engineering study of roadway and traffic conditions.*
>
> *Engineering studies should be made of operating signals to determine if the type of installation and the timing program meet the current requirements of traffic."*
>
> [Manual on Uniform Traffic Control Devices]

The purpose of this manual is to present the fundamental concepts and standard practices related to the design of traffic control signal systems within the State of Minnesota. This manual is structured to parallel the progression of decisions, activities and functions related to the design of traffic control signal systems. This is accomplished through the following chapters:

- ***Chapter 1*** addresses the activities required in the preliminary design stages. This includes the procedures for justifying, approving, planning and letting a project; the collection of data necessary for the design process; justification for signals; and a discussion on cooperative agreements.
- ***Chapter 2*** deals with the different types of operation and phasing associated with a signalized intersection and how that factors into the design process.
- ***Chapter 3*** includes the head placement charts used in the design process.
- ***Chapter 4*** describes the different types of detection systems used and the appropriate placement for the differing operational requirements.
- ***Chapter 5*** is a checklist for plan development.
- ***Chapter 6*** details the elements of the plan development. This includes signal plan sheet layout, CADD requirements, standard details, etc.
- ***Chapter 7*** covers the issues related to electrical distribution, such as, wire sizing and voltage drop, wiring types, detection, wiring diagram layout, etc.
- ***Chapter 8*** deals with signing and pavement marking and the relationship with the design process.
- ***Chapter 9*** discusses the types and format of specifications and estimating the cost to build the plan.
- ***Chapter 10*** is an introduction to Advanced Warning Flashers (AWF).
- ***Chapter 11*** is an introduction to signal pre-emption.
- ***Chapter 12*** is the sample plan set.

MANUAL REFERENCES

The pages contained within the manual are current at the time of publishing. Please keep in mind that the reference material is periodically updated, so the user is cautioned against using the reference materials included in the manual indefinitely, without checking the original sources for updates.

The following table lists the reference material used for this manual.

Traffic Engineering Manual (TEM) – October 2009
www.dot.state.mn.us/trafficeng/publ/tem/index.html
Minnesota Manual on Uniform Traffic Control Devices (MN MUTCD) – December 2011
www.dot.state.mn.us/trafficeng/publ/mutcd/index.html
Federal Manual on Uniform Traffic Control Devices (MUTCD) – January 2014
http://mutcd.fhwa.dot.gov/index.htm
Minnesota Statute on Utilities, Chapter 216D - 2013
www.revisor.leg.state.mn.us/stats/216D/04.html
Signal Design Documents
http://www.dot.state.mn.us/trafficeng/signals/index.html
Traffic Signal Timing and Coordination Manual – May 2013
http://www.dot.state.mn.us/trafficeng/publ/index.html
Sample Signal Design Plan Sheets – Dates vary
www.dot.state.mn.us/trafficeng/signals/signalplansheets.html
Signal Design Detail Sheets – Dates Vary
http://www.dot.state.mn.us/trafficeng/signals/signalplansheets.html
Sample Special Provisions – Dates Vary
http://www.dot.state.mn.us/trafficeng/signals/manual.html
MnDOT Standard Plates – Dates Vary
http://standardplates.dot.state.mn.us/StdPlate.aspx
Standard Signs Summary – 2009
http://www.dot.state.mn.us/trafficeng/publ/signsmanual/index.html
MnDOT Standard Specifications for Construction - 2014
www.dot.state.mn.us/pre-letting/spec/index.html

ACKNOWLEDGEMENTS

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DISCLAIMER

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1. PRELIMINARY SIGNAL DESIGN

The purpose of this chapter is to familiarize the designer and project manager (PM) with the comprehensive traffic control signal design process. The designer and PM will be introduced to the interrelationships of the design process.

The information following this sheet is a handout from Chapter 9 of the Traffic Engineering Manual (TEM), Traffic Signal Project Procedures. The most current version of the TEM can be found at:

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

It is recommended that you review all original reference material to check for updates.

or handicapped pedestrians.

9. Crash data: number and general types of crashes which have occurred for a minimum of 12 months before the date of the report. If Warrant 7 for crash experience is addressed, a collision diagram must be included, showing crashes by type, location in the intersection, directions of movement, severity, date, time of day, weather, light, and roadway conditions.
10. Any special site conditions: which add to the engineer's judgment that signals are necessary.

The information can be presented in either checklist or narrative form, so long as it is clearly and logically presented. Volumes can be presented in graph or tabular form.

A sample SJR can be found on the Office of Traffic, Safety,, and Operations website.

Signal Removal Justification Criteria

Signalized intersections that meet 80 percent of the volume requirements of MN MUTCD Warrant 1 should be considered justified and should not be removed. Signalized intersections that do not meet 80 percent of the volume requirements of MN MUTCD Warrant 1, but meet 60 percent of the volume requirements of Warrant 1 are in the gray area and should be considered for signal removal. Additional studies, findings, engineering judgment and documentation beyond the volume requirements will be needed to justify retaining the signal.

Signalized intersections that do not meet 60 percent of the volume requirements of MN MUTCD Warrant 1 and meet no other Warrant should be considered unjustified traffic control signals and should be removed. The traffic signal removal decision process shall be followed as set forth in the "User Guide for Removal of Not Needed Traffic Signals", FHWA-IP-80-12, November 1980.

In the traffic signal removal process, the District Traffic Engineer considers all the findings and the decision is made whether or not to remove the traffic signal. The final decision concerning signal removal is a blend of analytical procedures and political considerations coupled with professional judgment. However, the technical findings from the analysis should provide a strong factual basis for reaching, supporting and defending the final decision or recommendation.

All findings of the decision process shall be summarized by the District Traffic Engineer in a signal justification report or a signal removal justification report, if so determined.

All traffic signals that are determined to be retained should be revised to meet current standards. These traffic signals should be prioritized along with other traffic signal projects and scheduled for revision as permitted.

9-5.00 TRAFFIC SIGNAL PROJECT PROCEDURES

9-5.01 Traffic Signal Project Management Flowchart

The accompanying chart illustrates a typical state let traffic signal project management flowchart based on the deliverables and important milestones.

9-5.02 Notes on Traffic Signal Project Management Flowchart

A. START PROJECT

The Statewide Transportation Improvement Plan (STIP) and the Program and Project Management System (PPMS) identify the project and project manager. This is the beginning of tracking of the project.

Signal design projects can be characterized based upon the following parameters:

1. Contracting agency - Mn/DOT let versus local agency let, or force account.
2. Funding source - State Federal funds, Local Federal funds, state funds, state funds through a cooperative agreement, state aid funds, local funds.
3. Designer - Mn/DOT, consultant, design build contractor, and city.
4. Scope - Stand alone signal project or part of larger construction project.

B. PROJECT NOTIFICATION LETTER

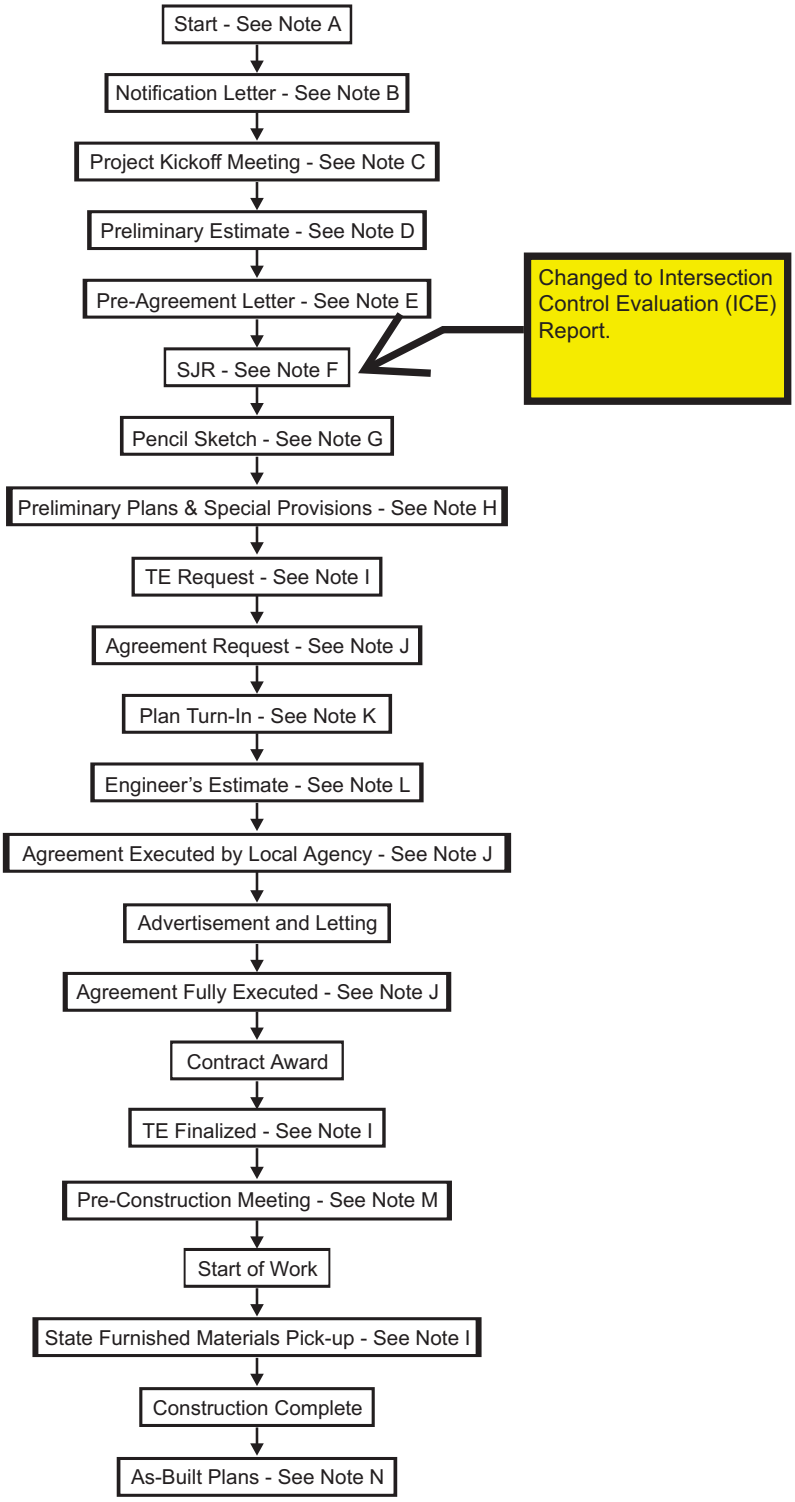
Early project coordination is the key to a successful review process. For Mn/DOT designed projects, the Project Notification Letter from the Mn/DOT district to the affected local agencies alerts the local agencies that a project is upcoming. The letter describes the project need and justification, scope, proposed letting date, expected construction duration, contact personnel (name, title, mailing address, phone, e-mail), funding source(s), and any need for in place plans and mapping.

For externally designed projects, the designer should send the Project Notification Letter to the Mn/DOT District Traffic Engineering office with similar information.

C. PROJECT KICKOFF MEETING

The designer should schedule a Project Kickoff Meeting to discuss the project scope, data collection findings and goals, and Mn/DOT and local agency issues and goals. The meeting's purpose is to make all project participants fully aware of all issues so that the project management, scope, funding, and technical issues are resolved prior to the beginning of signal design activities. This meeting should include the signal designer, local agency project manager (city, county, etc.), agencies affected by the project (cost, operation, maintenance) and Mn/DOT District Traffic Engineering office personnel.

In preparation for the Project Kickoff Meeting, the designer will begin data collection. The data to be collected (as needed) shall include: obtaining in place signal plans (or CADD files if available), obtaining mapping if available, identifying any current problems with signal operations and/or maintenance, identifying signal design standard or geometric deficiencies, checking for other proposed projects in the vicinity including project time lines, checking crash rates, checking existing cabinet/controller condition and compatibility, and obtaining a preliminary cost estimate for state furnished materials and labor.



Typical State Let Traffic Signal Project Management Flowchart

The following is the project Kick-off Meeting check List for each intersection affected by a project:

Project Management

Mn/DOT Traffic Engineering project manager
Project sponsor/lead (Mn/DOT, city, county)
Designer (Mn/DOT, city, county, consultant)
Project location (TH/Intersection)
Project process (Permit, S.A., local initiative/AM funding, Mn/DOT Programmed)
Proposed project time line

Project Scope

Work proposed (new signal, major/minor revision, EVP, phasing change, standard)
Project proposer's specific goals (lanes, phasing, heads, EVP, etc.)
Mn/DOT's specific goals (lanes, phasing, heads, EVP, etc.)
Affect/coordination with TMC systems
Affect/coordination with lighting systems
SJR/project memo required
Operation issues
Operation issues not addressed by proposed project
Maintenance issues
Safety/accident issues
Traffic engineering construction liaison scope of responsibilities

Changed to Intersection Control Evaluation (ICE) Report.

System Operation/Management

Use Cost Participation, Operations, and Maintenance Responsibilities Worksheet

Funding / Costs

State, City or County furnished materials and labor estimate for proposed work
Need for an agreement (signals/lighting) for this proposed work (Pre-agreement letter to follow, if necessary.)
Need for a permit for this work
Funding sources and Cost participation of proposed work

Technical Issues (Use Field Walk Checklist to Identify all Issues)

Field walk

Affect on in place SOP

Consider truck traffic

SOP meeting and notification letter needed

Equipment pad revisions needed

EVP sight lines adequate (vertical and horizontal)

Affect on in place interconnect - need for interconnect

Affect on in place HH's - need to be moved or receive replacement covers

Standards upgrades proposed / needed (LED, EVP, pedestrian indication, etc.)

Phasing review needed

Detection needs/changes

Striping/signing affected

Approach signing affected (review conflicts)/needed (coordinate)

Utility information and process/needs - notification letter and time line

Specification requirements (design, operations, CESU for EVP card delivery, etc.)

Pedestrian amenities status (ramps, sidewalk, indications, PB placement, markings)

LOOK UP! Locate overhead power lines and determine clearance requirements for proposed structures.

Further Contacts

Since the project scope can change as result of data review and this meeting, define what actions will be taken to inform all attendees and cc:s of project scope changes.

References

Refer to www.dot.state.mn.us\trafficeng site for checklists, details, standards, sample special provisions, and other significant information.

Refer to signal and lighting design manuals for processes and technical information.

D. PRELIMINARY ESTIMATE

A Preliminary Estimate will be the basis for the costs in the Pre-Agreement Letter. The Preliminary Estimate will include the preliminary construction contract cost and will additionally identify costs for state furnished materials and labor, and costs for design and construction engineering. As the project costs become better defined, the designer should update the Preliminary Estimate.

E. PRE-AGREEMENT LETTER

The District Traffic Engineering project manager will send a Pre-Agreement letter to affected local agencies and Mn/DOT offices identifying the following:

1. Preliminary Estimate with breakdown
2. Project scope
3. Funding and cost participation
4. Time line
5. Major/minor maintenance responsibilities
6. Power supply costs and responsibilities
7. Signal and coordination operation responsibilities
8. State, County or City furnished material / labor
9. Construction engineering costs

Batteries for the back up systems will be purchased and replaced by the state on the reimbursable basis.

See details of cost sharing in the Signal Design Manual and Mn/DOT Policy and Procedures for Cooperative Construction Projects with Local Units of Government.

F. Intersection Control Evaluation (ICE) Report

An ICE Report shall be approved by the Mn/DOT District Traffic Engineer. The report should be completed prior to or near commencement of signal plan development, but only after the project scope is clearly defined. See the section on ICE in the Traffic Control Signal Design Manual

G. PENCIL SKETCH

A "pencil sketch" or preliminary CADD drawing (usually graphics and charts - no pole or construction notes) of the new signal should be provided to the Mn/DOT District Traffic Engineering office for review. This will allow Mn/DOT to comment on important design elements (head placement, detection, phasing) prior to signal plan development. This will eliminate significant design changes once the signal design has begun, and is strongly recommended.

Signal designers should meet and confer to agree on preliminary signal design. The design topics to be discussed should include but not be limited to the following:

1. General nature of the signal project: new installation, minor or major revisions.
2. Phasing of the intersection, relation of proposed phasing to the traffic volumes and turning movements; use of protected-permissive left-turn phasing rather than protected-only; use of overlaps.
3. Determine design standards based on who will operate the system.
4. Use of 4- and 5-section heads and non standard bracketing.
5. Head type (LED, Optically programmed, etc.).
6. Appropriateness of poles and pedestals for the site.
7. Placement of signal standards to ensure legal placement of all vehicle and pedestrian signal indications. See the Signal Design Manual, for signal head placement diagrams.
8. Placement of pedestrian pushbuttons relative to signal standards and in place sidewalks and crosswalks.
9. Need for EVP and placement of components.
10. Detector placement and functions. See the Signal Design Manual for loop detector placement diagrams.
11. Placement and type of handholes.
12. Design of equipment pad.
13. Type of service equipment.

14 Discuss needs for combined pad with lighting and/or TMC.
15 Need for intersection geometric improvements.
16. For revised systems, the wording of the signal pole notes for the revision.
17. Need for AWF's, supplemental heads, etc.
18. House moving route needs.
19. Painting of signal.
20. Luminaires metered or unmetered.
21. Source of power (to determine cabinet location).
22. Interconnect (determine need and type, location of master).

H. PRELIMINARY PLANS AND SPECIAL PROVISIONS

The Mn/DOT District Traffic Engineering office project manager distributes the preliminary signal design package (as distinct from a roadway design package) for review to the Mn/DOT District Traffic Engineering office, District State Aid office, Cooperative Agreements, Consultant Agreements, Permits, Metro or Regional Electrical Service Unit, and other district functional offices as appropriate. The preliminary signal design package shall consist of the appropriate number of copies of signal plans (hard copies), signal special provisions, Microstation CADD file, Preliminary Estimate, source of power letter, and power application form (if applicable). The preliminary signal design package is required for all projects. The District Traffic Engineering office project manager works directly with the designer on format and technical comments, keeping other project managers informed.

The plan should identify the TE number, the system ID number, and the master ID number (if applicable).

NOTE: To expedite the signal plan review process, the signal plan should be checked by the signal designer prior to submittal. A checklist for plan reviews is available in the Signal Design Manual.

I. TE REQUEST

A Traffic Engineering (TE) Request is a work order requesting state furnished materials and/or labor from the Central Electrical Services Unit. Most signal projects let by Mn/DOT will utilize a state furnished traffic signal controller and cabinet. Other state furnished materials, especially for temporary traffic signal systems, may include microwave or video detection systems. In addition to the state furnished materials, a TE Request may also include a request for labor, such as modifying wiring within an existing signal controller cabinet in the field. The District Traffic Engineering office prepares and submits the TE Request in the AFMS system and the Central Electrical Services Unit approves it.

The project special provisions should require the Contractor to contact the Central Electrical Services Unit to request the state furnished materials at least 30 days before the materials are needed. The Central Electrical Services Unit will final the TE Request, which ensures that the materials are correctly charged to the signal construction project.

The project special provisions should require the Contractor to again contact the Central Electrical Services Unit 3 days before picking up the state furnished materials.

J. SIGNAL AGREEMENT

Mn/DOT shall prepare a signal agreement as needed. Items typically covered within the agreement are:

1. Construction cost participation
2. Responsibility for power cost
3. Responsibility for major maintenance
4. Responsibility for minor maintenance
5. Responsibility for maintenance costs
6. Responsibility for signal timing and operation
7. Costs and responsibility for Emergency Vehicle Preemption (EVP) systems
8. Reimbursement for State, County or City furnished materials / labor
9. Construction engineering costs

Batteries for the back up systems will be purchased and replaced by the state on the reimbursable basis.

There is a minimum of 12 weeks prior to construction for the structural steel delivery from the manufacturer.

The signal Agreement Request is often combined with the final Plan Turn-In.

Projects requiring signal agreements should not be let without the agreement signed by the local unit of government. The construction project should not be awarded without a fully executed agreement (signed by all parties).

Time and Traffic Special Provisions need to be included PRIOR to plan turn in.

K. PLAN TURN-IN

The Mn/DOT District Traffic Engineering office project manager ensures that all of the comments to the preliminary submittal have been appropriately addressed. Upon completion of the final review, Mn/DOT (either the District Traffic Engineering office project manager or the larger roadway project manager) will begin final processing of the project package. Once all the district and local signatures are obtained, the project will be submitted to the Pre-Letting Section of the Office of Technical Support for final processing.

Traffic signal plan approvals 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 Traffic Engineer shall approve the final plans before bids are opened on the project. If a proposed signal is not at a trunk highway location, the District Traffic Engineer will indicate concurrence with the design by means of a memorandum to the State Aid office.

The project submittal package shall include:

1, Hard copy and Microstation CADD files of the signal plans
2. Hard copy and Microsoft Word files of the signal special provisions
3. Tabulation of Quantities for the signal project

L. ENGINEER'S ESTIMATE

The Office of Technical Support prepares the final Engineer's Estimate based upon the tabulation of quantities provided by the signal designer.

M. PRECONSTRUCTION MEETING

For the Pre-construction Meeting the District Traffic Engineering office project manager should invite the Mn/DOT District Traffic Engineering office operations personnel as appropriate.

N. AS-BUILT PLANS

"As-Built" also called "Record Plan"

As-built signal plans should be forwarded to the Mn/DOT District Traffic Engineering office upon completion of projects administered by local agencies.

9-6.00 TRAFFIC SIGNAL DESIGN

9-6.01 General Considerations

The design of a traffic signal system is a process of balancing, among other things, the requirements of MN MUTCD, intersection geometrics, operational characteristics of the intersection vehicle and pedestrian traffic; the nature and volume of arterial traffic; and the constraints of the construction process. Please see the traffic signal project management flowchart.

See the Signal Design Manual for more detailed information.

9-6.02 Intersection Geometry

Intersection geometry is an important element of traffic signal design. The design of traffic signal system hardware and operation of the traffic signal system should be preceded by a thorough evaluation and, if necessary, geometric improvement of the existing intersection.

The following geometric elements should be considered:

1. Pavement width should be adequate for anticipated traffic movements and future capacity requirements. Highway capacity analysis should be performed to get a better understanding of the capacity of the intersection.
2. If appropriate islands should be designed and constructed so that the driver has adequate reaction distance to them and they are large enough to install a standard signal foundation. Existing shoulders should always be carried through the intersection; this will usually provide enough reaction distance to the island. However, turning radii should be checked to ensure enough setback for comfortable turns.
3. Turn lanes must provide adequate storage in order to prevent turning traffic from interfering with other traffic movements and thus causing capacity breakdown.
4. When a median width is more than 30 feet between opposing through lanes, special signal design considerations are necessary (See MN MUTCD, Section 4H). Extremely wide medians confuse drivers on the crossing street, prevent them from being comfortable with opposing traffic, and cause them to lose track of their path. Wide medians also cause capacity restrictions because more time is needed for vehicle movements and clearances through the intersection.
5. Sidewalks should be constructed as close to the center of the corner as possible. Pedestrian crosswalks should be inline with sidewalk and as close to the intersection as practical.
6. Alignment changes within the intersection should be avoided. Vehicles approaching the intersection should be directed through the intersection. Vertical alignments approaching signals must allow for proper signal visibility.
7. Driveways within an intersection should be signalized and accommodated by the intersection geometrics. Whenever feasible, the driveways should be located or relocated outside the limits of the intersection.

8. The size of corner radii is an important consideration. Excessively large corner radii may obscure intersection limits and create a hazard for bicycles and pedestrians, while very small radii may create a hazard for motorists. Corner radii at signalized intersections should not be less than 20 feet nor more than 60 feet. A turning radius guide for 58-foot vehicles should be used to determine proper corner radii. At intersections where bus routes are located, corner radii should be analyzed giving due consideration to bus maneuvers.
9. It may be necessary to relocate utilities such as manholes, catch basins, fire hydrants, overhead power and telephone lines and power poles, to obtain adequate geometrics for signalization. The existence of these utilities must not get in the way of adequate geometrics.
10. Pedestrian curb ramps are required at all corners.

9-6.03 Operational Characteristics

Saturated approaches should have an upstream count taken to determine the demand volume rather than the service volume at the intersection.

The behavior of the traffic at an intersection is another highly important element of signal design. The following elements should be considered:

1. Existing 15-minute vehicle volumes, by vehicle class, and pedestrian volumes, are the most basic operational consideration. Data used should represent intersection operation in peak periods.
2. Intersection capacity should be determined based on the Highway Capacity Manual and other sources.
3. The vehicle approach posted speeds should be determined for the location of advance detection.
4. Adjacent land uses should be evaluated to identify activities which may conflict with intersection operation. Items which should be considered include entrances, advertising devices, and areas of high pedestrian activity (schools, manufacturing plants, shopping centers, etc.).
5. Crashes within the intersection should be studied to determine causes and possible design solutions.
6. Pedestrian volumes and school-crossing activities should be studied to determine pedestrian routes and necessary design treatments. Pedestrian movements in and around signals should be routed into the intersection crosswalks in front of vehicles stopped for the signal.

9-6.04 System (Arterial) Considerations

In many cases, an individual traffic control signal must be considered as part of a system, either as one of a series of signals along a linear route, or as one signal in a grid network. System considerations in signal design should include but are not limited to the following:

1. Adjacent signals should be interconnected whenever they are less than one-half mile apart, when the travel time between adjacent signals is less than the cycle length at each signal, or when platoons leaving one intersection remain intact to the next signal.
2. Properly spaced signalized intersections greatly simplify coordination in planning new signals. Minimum spacing of one-quarter mile is recommended. Irregular signal spacing reduces the overall operational efficiency of the mainline movements and greatly complicates signal coordination.
3. Whenever possible, platoons should be kept intact to allow easier mainline coordination and minimize cross-street delay.
4. New street or roadway construction should anticipate the need for future signals and the need for handholes and conduit, particularly under the roadway.

Provide pedestrian refuges in medians 6 feet and wider

5. Pretimed controllers are used in built-up urban environments, particularly central business districts. The streets are not excessively wide and the traffic patterns are quite predictable. In this environment, a signal cycle should contain pedestrian movements. Actuated controllers are used in suburban and rural environments. In the rural environment, the actuated controller tends to reduce the number of stops and does not cut off platoons of vehicles. In the suburban environment, the arterial streets tend to be very wide, and the volumes are usually quite high on these arterials. There are not usually many pedestrians crossing such an arterial, so an actuated controller tends to operate much more efficiently, as it is not necessary to time pedestrian intervals except when an actual demand exists.
6. Splits and offsets should be carefully estimated to determine their impact on arterial flow. A split is the relative percentage of green time allocated to each of the various phases at a single intersection. An offset is the travel time between signals, usually expressed in percent of cycle length.
7. Minimum pedestrian walk and clearance timings should be anticipated when designing coordinated signal systems.

9-6.05 Signal Design Elements

1. The most efficient operation of a signal system is attained with the fewest phases that are enough to move traffic without hazardous conflicts. Procedures exist to determine the optimum number of phases for an intersection. See the Signal Design Manual for a discussion of phasing considerations.
2. 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 faces shall conform to the requirements of Sections 4D-15, 4D-16, and 4D-17 of the MN MUTCD. Overheads should be located as near as practicable to the line of the driver's normal view. When an overhead is to control two lanes, it should be installed over the lane line dividing the two lanes. An overhead should be used over each lane when speeds are above 40 mph. The size of lenses shall be as stated in section 4D-15 of the MN MUTCD. See the signal head placement charts in the Signal Design Manual. In general, vehicle signal faces 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. The Horizontal Location of Signal Faces shown in MN MUTCD Figure 4D-6 should be used as an aid in placing vehicle signal faces.
3. Vehicle detectors should be placed according to the detector spacing chart and the loop placement diagrams shown in Signal Design Manual.
4. At locations where pedestrians are expected, provisions must be made to control pedestrian activity in and around the signalized intersection. At locations where pedestrians are expected, pedestrian indications shall be provided if minimum pedestrian crossing time exceeds minimum vehicular green time, or if any of the conditions set out in section 4E.3 of the MN MUTCD are met. Pedestrian push buttons should be installed at locations with pedestrian activity where it is not operationally efficient to provide pedestrian timing on every cycle. Pedestrian signal indications shall be mounted, positioned, and aimed so as to be in the line of pedestrians' vision, and to provide maximum visibility at the beginning of the controlled crossing.
5. If it is determined to prohibit pedestrian movement across any approach, that prohibition must be clearly visible to pedestrians by use of Standard Sign R9-3a on each side of the prohibited crosswalk. See part 4 of the MN MUTCD for further information.
6. Street lighting should normally be installed with traffic signals and flashing beacons. The luminaires are generally 250-watt high-pressure sodium vapor luminaires, mounted in the far-right quadrants of the major street. Larger intersections may require additional luminaires. Forty foot mounting heights provide even light distribution. Street lights installed on type A signal mast-arm poles should be mounted at approximately 350 degrees clockwise from the mast arm in order to provide frontal illumination of any signs mounted on the mast arm. LEDs are becoming the typical roadway lighting unit.

Signal design must take into account the existing adjacent lighting systems and the equipment available to provide access to the luminaires for relamping and maintenance. The presence of overhead power lines must also be taken into account. These must be designed around or moved.

A document called the Signal Design Review Check List is in the Signal Design Manual.

9-7.00 TRAFFIC SIGNAL PLANS AND SPECIFICATIONS

9-7.01 General

The end products of the pre-construction activities in signal design are the Plan, Special Provisions, and Engineer's Estimate. Supporting the Plans and Special Provisions are the standard design practices, Standard Plates Manual, the Mn/DOT Standard Specifications for Construction, other applicable national and local standards, and any necessary agreements. Detailed information is shown in the Signal Design Manual.

9-7.02 Traffic Signal Plans

The districts develop plans. If the districts desire they may request the review of plans by the Office of Traffic, Safety, and Operations.

9-7.03 Special Provisions

The Special Provisions for signal projects include complete detailed specifications of the signal system(s) and Maintenance of Traffic section which details the contract time schedule and provisions for traffic during construction. The Special Provisions are project specific specifications that supplement the Mn/DOT Standard Specifications for Construction book.

Responsibilities related to the Special Provisions are as follows:

1. District Traffic Engineer
   a. Submits to the Special Provisions Engineer of the Office of Technical Support the Special Provisions for Mn/DOT designed signal system projects. The Special Provisions shall be submitted in accordance with the pre-determined "Project Pre-Letting Date" deadlines.
   b. Submits to the Special Provisions Engineer in the Office of Technical Support a completed copy of Form 21184, Contract Time Schedule Recommendations and Misc. Data and Form 21185, Provisions for traffic During Construction. This information shall be submitted in accordance with the pre-determined “Project Pre-Letting Date” deadlines.
2. Office of Traffic, Safety, and Operations, Signal Unit
   a. Upon request of the District, reviews Special Provisions for signal system projects let by the State or other agencies involving the trunk highway system. The Office of Traffic, Safety, and Operations website will maintain sample Special Provisions for District, Consultant, and other Agencies to access.

9-7.04 Tabulation of Quantities

The Detailed Construction Estimate (Engineer's Estimate) for all signal system projects let by the State is prepared by the Office of Technical Support. The District is responsible for providing a detailed tabulation of quantities to the Office of Technical Support as a basis for the Engineer's estimate. The Signal Design Manual provides a sample tabulation of quantities.

1.1 DATA COLLECTION

Before a traffic control signal system is designed, various pieces of data must be collected. The data collected is used to perform the engineering study to determine if the signal is warranted. Other uses for data is to determine the appropriate signal phasing for an intersection and how that operation effects the design, classify vehicles and determine how that vehicle mix effects placement, etc.

When collecting data, it is important to collect pedestrian counts when pedestrians are present. This information is needed for studies and signal timing. This data will also aid in the decision to add pedestrian facilities including APS systems to the intersection.

In this section, some of the data collection items required for traffic control signal systems is discussed.

The information following this page is a handout taken from Chapter 5 of the Traffic Engineering Manual (TEM). The most current version of the TEM can be found at:

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

It is recommended that you review all original reference material to check for updates.

Sample Size - The number of observations made. Sample size needed for statistical reliability depends on the variability of the population (as reflected by variance or standard deviation) and the level of confidence needed. Sample sizes smaller than n = 30 are generally considered too small.

Significance - statistical significance implies that the differences found are likely to be real and not due merely to chance. The significance level for a test represents the weight of evidence for rejecting *Ho*, i.e. the probability of observing a sample outcome more contradictory to *Ho* than the observed outcome. This level of significance is usually called P. Thus if P = 25, there is a 25% chance of having found a more extreme value even if *Ho* were correct. It should be noted then that P is really an α value which has been computed for our particular findings rather than being preset. Confidence may be reported as 1 - α or 1 - P depending upon how results are reported.

Skew Index - A measure of symmetry of the distribution about the mean. A "normal" distribution, symbolized by a bell-shaped curve, would have a skew index between 0.90 and 1.10, and is indicative of randomness of observed values. A positive skewness (> 1.10) is caused by a preponderance of higher values in the sample. A negative skewness (< 0.90) is caused by a preponderance of lower values. The skew index is highly susceptible to minor changes in the distribution. If the value obtained indicates the presence of skewness, consider the possibility that the environment or even the presence of the observer was adversely affecting data.

Skew Index Variance - The variance of the skew index.

Standard Deviation - (Std-Dev), the square root of the variance, another measure of variability used for statistical tests.

Standard Error of the Mean - (STD-ERR), the standard error is the standard deviation divided by the square root of the sample size. The standard error is used to determine the accuracy with which the mean has been determined.

Variance - (VAR), a value calculated based on differences between individual observations and the average of all observations. High values of variance indicate greater variability between observations. The variance is used in statistical computations.

85th Percentile Speed - The speed at or below which 85 percent of the observed vehicles are traveling. This factor is commonly used in establishing speed limits.

5-3.00 VOLUME COUNTS

5-3.01 Types of Traffic Counts

Traffic counts are the most basic type of data collected in the field of traffic engineering. Quite simply, traffic counts involve counting vehicles passing a point for varying intervals of time. They can range from 24 hours per day, 365 days per year, to five minutes of a peak period. Common types of traffic counts, count intervals and the regular traffic counting program of Mn/DOT, are described below. In addition to their use for purely traffic engineering purposes, traffic counts are used to determine vehicle miles of travel for the purpose of distributing gas tax revenues throughout various levels of state and local government.

5-3.01.01 Total Volume Counts

The principal use of traffic volume data is the determination of average daily traffic (24 hours) on a particular segment of roadway. The most common product of traffic volume data accumulation is a traffic map identifying the volume of traffic on major roadways. Traffic counts are also used to identify the highest volume of traffic occurring on a segment of roadway during a specific time period, such as the peak period (e.g., 6-9 A.M., 3-6 P.M.), the peak hour, or 5 and 15-minute peaks within the peak period.

5-3.01.02 Directional Counts

Directional counts are counts taken of traffic movements on a roadway by direction of travel. On a segment of highway, directional counts include counts of each movement past the point at which the count is being taken. At an intersection, directional counts are made of each possible movement-through movements by direction of travel, and left and right turns by direction of travel.

5-3.01.03 Lane Counts

Lane counts are directional traffic counts taken for each travel lane on a multi-lane roadway.

5-3.01.04 Pedestrian Counts

Pedestrian counts are counts of the number of people walking through the area being studied. Pedestrian counts are normally taken only between 8 A.M. and 6 P.M.

5-3.01.05 Metropolitan Freeway Counts

In addition to other counts, each metropolitan area freeway segment is being counted at least once every two years as part of a program monitoring peak period operating conditions. These counts (either 5, 15, or 60-minute increments) are used to determine if congestion is becoming, or has become, a problem; and if so, what corrective measures (such as ramp metering) can be used to alleviate the problem. The Metro District works in cooperation with the Transportation Data and Analysis Section (TDA), Office of Planning, Modal and Data Management Division to gather and analyze this data.

5-3.02 Regularly Conducted Counts

The Department conducts five regular traffic counting programs throughout the state. These programs are summarized in Table 5.1 and described below.

PROGRAM	WHERE CONDUCTED	FREQUENCY	NUMBER OF COUNTS MADE
1. ATR Program	Outstate Municipal CSAH Outstate Rural CSAH Outstate Municipal TH Outstate Rural TH 7-County Metro Area	Continuous	125
2. Rural TH	Rural TH Municipal TH	Every other year (even numbers) 48-hour counts	6,000
3. County and Municipal	County and Municipal CSAH CSAH	Over a four year period -- 48-hour counts	27,000
4. Municipal State Aid	State Aid streets within municipalities	State Aid streets within municipalities	4,000
5. Seven-County Metro	Sample of TH and other	Sample of TH and other	9,000

Text Ref.: 5-3.02

July 1,1991	TABLE OF DEPARTMENT TRAFFIC COUNTING PROGRAMS	TABLE 5.1

5-3.02.01 *Automatic Traffic Recorder Program*

1. **Location** - Automatic traffic recorders (ATRs) are permanently installed at approximately 125 selected locations throughout the state. These ATR locations were selected to best represent statewide travel and are usually located on trunk highways. Locations on other than trunk highways are determined by population, average daily traffic, and land use. ATR locations in the eight county metropolitan area are based on locale; they include urban, suburban, and outlying areas with road use characteristics that are commuter, mix, and recreational. Combining area classifications with road use classifications - urban commuter, suburban mix, etc., comprise the spectrum of ATR locations in the metropolitan area.

2. **Data Collection** - ATRs are permanently installed and continuously record traffic volumes by direction of travel. All data is accumulated by hour. Approximately one-fourth of the ATRs determine the speed and length of vehicles passing their locations. These are then sorted into one of 12 speed ranges and one of two length categories. Data is retrieved from all locations via telephone lines. A central controller polls each location and stores this data by location and date. This data is processed and edited. Monthly reports are prepared showing hourly volumes and appropriate totals and averages. An automatic Traffic Recorder Data Report is published each year showing monthly ADT for the current and previous year for all ATRs. A Traffic Recorder Data Summary is also published annually. This shows days of week, monthly relationships to average daily traffic and to average summer weekday traffic, peak hours of travel, and average hourly traffic. Graphs included show volume variations throughout the year. These reports may be obtained from the TDA Section.

5-3.02.02 *Portable Traffic Counting Program*

1. **Location** - Forty-eight hour machine counts are taken on designated outstate roadways, and on highways in the eight county metropolitan area. Portable traffic counting programs involve placing traffic counters at selected locations to obtain traffic estimates. The sample locations are determined by the TDA Section.

2. **Data Collection** - These counts are taken by personnel in the district offices, and are sent back to the TDA Section where they are coded by road use. ADT is estimated by applying an appropriate seasonal and weekly adjustment factor. ADT estimates are plotted on work maps where they are compared to historical traffic and land-use data to determine final estimates of average daily traffic. The total number of counts and the time period required to complete the portable traffic counter program are shown in Table 5.1.

5-3.02.03 *Computerized Data Collection*

1. **Special Counts** - Special Counts are conducted within the metropolitan area on I-35W, I-94, I-494, I-694, and associated ramps. There are approximately 800 permanent vehicle loop detectors currently being monitored by computers at the Regional Traffic Management Center (RTMC) in Roseville. Volume and occupancy data from these detectors are used to determine operational parameters and evaluate the effectiveness of the traffic management systems on these freeways.

   Data is collected in either 30 second or five minute intervals depending on operational needs. This data is then retained for varying lengths of time. Five minute volume and occupancy counts from detectors are available from computer disk files dating back to January 1, 1994. However, data availability usually lags by one day. Counts may be printed from these files at any interval desired, from five minute to 24 hours. As other newly constructed or reconstructed segments of freeway are added to the metropolitan area network, loop detectors will be installed and added to the number of locations already monitored from the RTMC. In addition to detectors installed for traffic management operational needs, detectors are being installed to help reduce the use of portable tube-type counters with their attendant problems and hazards. This should benefit planners and others needing traffic counts from Metropolitan freeway systems.

2. **Tape Processing** - Many portable traffic recorders are designed so that the recorded tape can be read either manually or by translating equipment. These translators convert the coded data into computer format to obtain the desired summaries.

5-3.03 Equipment

Video collection units are becoming more common for traffic counts.

5-3.03.01 Traffic Counters

1. **Description** - Manually operated traffic counters are a commonly used piece of equipment for manual counts, especially for turning movement directional counts. Traffic counter boards are composed of a number of hand-operated counters arranged so that each approach lane to a conventional four-legged intersection is represented by a counter. Usually, a piece of tape is placed in front of each counter row, upon which the observer marks the direction of the movement being counted-through, right turn, left turn, etc.

2. **Operation** - Operation of the counter board is simple. At the start of the count, each of the dials is read and the reading is indicated on a recording form. As each vehicle passes the observer, the counter mechanism is depressed for that particular movement. At prescribed intervals as predetermined by the data requirements - 5-minute, 15-minute, or hourly - the counter is read and the number is recorded. There is no need to set back the counter to zero although most counters are designed to permit this. The actual traffic volumes are determined by subtraction of the initial reading from the final reading.

5-3.03.02 Portable Traffic Recorders

1. **General** - Portable traffic recorders are either accumulative or nonaccumulative. In either case, the machine which is usually used has a rubber hose (or road tube) over which the vehicles to be counted pass. At permanent locations, a fixed loop detector permanently imbedded into the roadway is utilized to detect vehicles for machine counting.

2. **Accumulative Counters** - An accumulative counter is termed "accumulative" because the counter bank continually advances. Therefore, the counter must be directly read at preselected times. The main parts of an accumulative counter are: (1) the road tube, (2) a dry cell battery to power the unit, (3) a diaphragm, and (4) a counter bank. A surge of air through the tube, caused by a vehicle depressing the tube, deforms the diaphragm and thereby completes an electrical circuit which transmits the electric impulse from the batteries to advance the counter. In most cases, one depression of the road tube advances the counter bank one-half number; two depressions result in one full advancement of the counters or an increase of one number in the counter reading.

3. **Nonaccumulative Counters** - A nonaccumulative counter operates on the same principle as the accumulative counter. However, the nonaccumulative counter records only at specific time intervals - usually 15 minutes - and the recording is made directly upon a paper tape. Only the count for that particular time interval is recorded. Figure 5.1 shows typical portable traffic recorder printed tapes with examples of the recorded data. Both the time and the traffic count are recorded on the tapes. Typical data increments are 15 minutes or one hour. The machines with electronic clocks can be set for intervals as short as one minute.

   a. **Quarter Hour Counts** - The quarter hour record is most widely used because it permits the identification of traffic volumes by quarter-hour intervals, which is useful in the determination of peak-hour volumes. The quarter-hour counter also accumulates the traffic count for the hour clock interval. Both the first 15-minute count and the total counts for that hour can be read directly from the tape. Quarter-hour counts between the beginning and ending of the clock hour must be obtained by subtraction. The count during any quarter-hour period is, thus, the difference between any two counts printed opposite the quarter-hour intervals.

   b. **Hourly Counts** - The hourly count merely totals the count during the hour interval, prints the hourly volume, resets the counter to zero, and advances the hour indicator.

5-3.03.03 P.C. Compatible Counters

1. **Manual** - Used primarily for intersection/turning movement studies, a manually operated 12-button panel can be used in conjunction with a counter that is preprogrammed with the necessary parameters such as date, starting time, site identification, and desired time intervals (generally 15 minute). Form 5.D (Mn/DOT 2944A Rev.) is used in the field with the counting operation so that each movement can be identified with a specific button on the panel. Upon completion of a study the counter can be returned to the office and the count data transferred to a P.C. compatible retriever. Once the retriever is connected to a computer, printouts can be made containing a variety of information such as 15 minute totals for each movement, hourly totals, total intersection volumes, and AM and/or PM peak volumes. An example of these printouts can be seen in Figures 5.2, 5.3A, and 5.3B.

   A second type of manual counter is a microprocessor-based device designed specifically for manual counting. This device has 16 buttons of which 12 are keyed to intersection movements, the remaining four buttons can be used for counting pedestrians, trucks, or buses. Up to 12 hours of count data are automatically stored in the memory in five or 15 minute intervals. Data can be read directly from the counter or transferred to a computer for analysis and printout.

2. **Portable Recorders** - Portable recorders that are P.C. compatible generally consist of two pieces of equipment, a traffic counter and a retriever. The counter is a nonaccumulative portable recorder that is used in the field with associated tubes or loops to obtain volume counts over a prescribed length of time, usually 48 hours. The retriever is used to monitor, set parameters, and collect the stored data from the counter. Prior to beginning a study, the retriever is connected to the counter and various parameters such as time intervals, date, and start time are set. Once the parameters have been set the retriever is disconnected and the counter is left to accumulate the needed data. When the desired study time has elapsed the retriever is returned to the site and reconnected to the counter. The accumulated data is then "dumped" from the counter into the retriever. The retriever is returned to the office, connected to a P.C. and the desired printouts made.

5-3.03.04 Counter Maintenance

1. **ATR Stations** - All of the maintenance of the ATR stations is performed by the Office of Maintenance, Electrical Services Section (ESS). The cost of the power to operate each station is paid for by the District Office that each station is located in. Phone bills are processed by the Business Administration Unit of the Program Management Division.

2. **Portable Traffic Recorders** - The portable traffic counter cases, hoses, chains, and chain locks are maintained and budgeted for by ESS. All counters needing repairs should be transported to the ESS. It is best to spread out the maintenance of counters to avoid delay due to work overloads.

The goal at ESS is to provide repair service when defective counters are turned in. At times, vendors will be used to do some of the repair work. All portable counters are listed in the Office of Maintenance inventory.

Shortly after the first of July each year, each district must advise the Office of Maintenance of the number of counters required to maintain this counting program. This report goes directly to the ESS and is incorporated into an annual budget request for additional and replacement counters.

5-3.04 Field Data Collection

5-3.04.01 ATR Program

All automatic traffic recorders are in permanent locations. These locations are recorded in the "Minnesota Automatic Traffic Recorder Data Summary" prepared by the TDA Section.

5-3.04.02 Portable Counter Placement

Care should be taken in selecting the location for installing portable traffic- counting equipment. There are two crucial location considerations: (1) placement of the road tube and (2) security of the traffic counter. The selection of an appropriate time and day for counting should also be coordinated with street maintenance and cleaning schedules to avoid road tube damage by maintenance vehicles.

1. **Road Tube Placement** - The road tube should be located along a smooth portion of the roadway to be counted. The hose should not fall along a construction joint as the roadway depression at the joint could cause a misreading of the tube. Care should also be taken to locate the hose far enough away from intersections so that any vehicle crossing the hose would still be moving at right angles to the hose and not turning across the hose. The offsetting of wheels during vehicular traffic turning movements could cause a traffic counter to misread if the counter were located within the turning arc. In securing the roadway tube, PK concrete nails are commonly utilized. The far end of the roadway tube has a clamp through which the PK nail is inserted and driven into a crack in the roadway or, ideally, into the construction joint between the gutter section and the pavement edge. A clamp is also usually attached to the hose at the near side of the counter. This clamp is affixed to the roadway with a nail driven into the construction joint between the gutter section and the pavement edge. Tubes are especially vulnerable to damage by snow plows so they should not be used during inclement weather.
2. **Security** - Traffic counters should be securely chained to a sign post, utility pole, or light pole to prevent theft.

5-3.04.03 Other Considerations

Machine numbers should be recorded on the data tape so that corrections can be made if maintenance problems or bad data are encountered. The date, direction of travel, location, and other identifying information should also be included. A length of blank tape should be left on both ends to permit proper machine processing.

5-3.05 Data Recording Forms

This section describes the standard forms utilized for many of the traffic counts described above. Standardized forms are not available for the collection of all data described in this chapter.

5-3.05.01 Data Sheets

Examples of forms used to record data from the portable counters are shown in Form 5.A (Mn/DOT 2914 (5-77)) and Form 5.B (Mn/DOT 29176 (3-77)). Form 5.A is used for recording data from accumulative counters while Form 5.B is used for recording data from nonaccumulative counters.

Accumulative counters must be read directly and the number read should be placed on a form for the appropriate time period. These numbers are then translated to actual volumes by subtraction and the result entered below. Where hourly counters are used, the recording tapes are collected and the traffic volumes are transferred to Form 5.B in the office. Traffic volume data from counters that are P.C. compatible will be produced on computer printouts such as those shown in Figure 5.5A.

5-3.05.02 Directional Counts

Directional, or turning movement counts, are generally taken during AM and/or PM peak periods and are recorded on either a Motor Vehicle Traffic Volume and Turning Movement Field Report or a Traffic Volume and Turning Movement Study or a , Form 5.C and Form 5D (Mn/DOT 2944 Rev) respectively. For examples, see Figures 5.2, 5.3A and 5.3B.

5-3.06 Sample Sizes

Depending on the purpose of the study, sample sizes can vary from a fraction of an hour to 24 hours a day, 365 days a year. Generally, peak periods will be included in all samples. Traffic counts are normally not taken on a holiday nor on the day before or after a holiday. Monday mornings and Friday evenings will generally show high volumes.

Typical sample sizes are:

	Type of Study	Sample Size
1	ADT	24 or 48 hrs.
2.	ATR	24 hrs./day, 365 days/yr.
3.	Signal Warrants	8 to 12 hrs. including both peak periods
4.	Vehicle Classification	16 hrs.

5-3.07 Computations

5-3.07.01 Data Review

The first step in utilizing field data is to check its reasonableness by comparing the data with data obtained from similar locations. If the data is not comparable, the equipment and the field data sheets should be inspected for malfunction or error; and an additional count should be taken for verification.

5-3.07.02 Factoring

The TDA Section provides the necessary factors for adjusting weekday machine traffic counts to estimated average daily traffic. These factors are derived from individual counts or groups of counts produced by the automatic traffic recorders. Since all frequencies of data (hourly, daily, weekday, day of week, monthly and ADT) are available at each ATR, the relationships or factors that can be identified and developed are almost unlimited. All factors and factoring procedures are developed and applied by the TDA Section.

5-3.07.03 Average Daily Traffic from 48-Hour Portable Counts

Average Daily Traffic estimates can be obtained based upon the portable 48-hour traffic count by applying the appropriate weekday or weekly factor to the count data.

5-3.07.04 Data Summaries

Many types of data and related factors can be developed from the ATR data. Currently these data are summarized in the "Automatic Traffic Recorder Annual Report" available from the TDA Section. The types of data recorded within this report for each ATR station are shown in Figures 5.5A through 5.5E.

5-3.08 Uses of Volume Counts

Volume counts play a major roll in traffic engineering. Their uses include:

1. Determining the need for traffic control devices
2. Obtaining various factors (hourly, daily, weekly,etc.)
3. Developing traffic flow maps
4. Research studies
5. Operational studies
6. Determining ADTs
7. Determining peak periods and peak hours
8. Signal phasing and timing
9. Determining trends
10. Determining the need for channelization
11. Simulation studies
12. Vehicle classifications
13. Calculating crash rates

5-4.00 SPOT SPEED

Spot speeds are the vehicle speeds taken at a specified point along the roadway. The average of such speeds is sometimes referred to as time mean speed.

5-4.01 Equipment

Spot speeds are usually collected by the use of radar or laser equipment, although spot speeds may be gathered during travel time runs by reading the speedometer at specified points along each run. Another method involves the use of a short "speed trap." This trap may consist of a short marked area on the roadway over which vehicles are timed and speeds computed, or may consist of a very short section beginning and ending with vehicle sensors (tubes or electronic) over which an electronic data collection device computes and records vehicular speeds.

5-4.02 Field Data Collection

Regardless of data collection method, the location of collection vehicles, personnel and equipment is of primary importance. The obvious or obstructive presence of these may have a large impact on the speeds of passing vehicles. Because of this, all equipment and personnel should be employed in the most inconspicuous manner possible, and note should be made when reporting information in cases where it is believed vehicular speeds were significantly affected by collection activities. Regarding radar speed collection, the following should also be considered:

1. The angle between the radar and the vehicle path affects speed readings. The further the radar is from a straight roadway section, the slower the speed will read. Although trigonometric adjustment can be made to correct these readings, it is generally more advisable to keep collection in as direct a line with oncoming traffic as possible, which usually means as close to the roadway as possible. Exception to this must be made when the collection vehicle and equipment would tend to affect vehicle speeds significantly.
2. Depending on the use of the data, the observer must consider whether to collect speeds of all vehicles, including platooned vehicles, or only the speeds of unimpeded vehicles. One may collect all speeds, for example, to assess traffic flow during peak periods; whereas only unimpeded vehicle speeds would be collected to assess the impact of speed zone signing.
3. Speed samples may be biased due to larger or faster vehicles being more easily picked up by radar, and vehicles screening vehicles directly behind them. These considerations must be kept in mind both while collecting and while analyzing data. Laser speed detection devices can collect discrete vehicles.

5-4.03 Data Recording Forms

Typical data recording forms, one filled out and one blank, are shown in Figure 5.6 and blank Form 5.F, respectively.

5-4.04 Sample Size

As a rule of thumb, at least 100 speeds should be collected within the time period under consideration. This will generally provide mean or 85th percentile speeds within ± one mph with 95% confidence. Samples must always be both random and representative. Use a sampling plan which does not distort (bias) values you are looking for. The largest sample size possible is often dictated by the volume at the location and/or the time period being studied. If the volume is very light or the time period very short, large sample sizes may not be possible. In these cases, a minimum sample size of 30 vehicles must be collected. For ordinary conditions this will provide an estimate of mean or 85 percentile speed. The limited data that is gathered should be analyzed by personnel familiar with small sample statistics. It should be noted that the information derived from very small samples may not be adequate for some uses.

5-4.05 Computations

Speed calculations can be done manually, but are usually done with an Excel spreadsheet which is available from OTSO. The basic procedure is to tally the number of vehicles in any one speed category (see Figure 5.6 and Form 5F), accumulatively add the vehicles for each category, and translate the accumulative totals to percentages. A pace (the 10 mph band where most observations occur) is then indicated on the field survey sheet by a vertical arrow. A horizontal arrow is used to indicate the 85th percentile speed.

5-4.06 Uses of Spot Speed Data

Vehicle speed data are used for many purposes including:

1. Establishing speed zones
2. Crash analysis
3. Environmental impacts (noise and air analysis)
4. Designing safety appurtenances
5. Evaluating traffic signal locations
6. Assessing the need for advisory speed limits
7. Setting signal clearance intervals
8. Assessing enforcement needs
9. Assessing speed trends
10. Conducting before/after analysis of various
11. geometric, traffic control, or legal changes

5-5.00 TRAVEL TIME AND DELAY

Travel time studies involve recording the time it takes vehicles to traverse a specified length of roadway. This stretch of roadway may include one or more intersections, or may be a relatively long stretch of freeway. In any case, a long "zone" is often broken into shorter, individually analyzed "links." Travel time data is often reported in terms of delay (travel time in excess of free-flow, unimpeded travel time) or of average speeds in links or zones.

5-5.01 Types of Delay Studies

Delay studies can be broken into two broad categories. The first category is delay caused by traffic flow conditions rather than by traffic control devices. The prime example of this would be delay occurring along a segment of freeway. In this case, most delay is due to slowing in response to congestion, although some stopped delay may also occur. Delay is considered to be excess time spent in the segment above what would be spent if travel were free-flow. The base free flow speed may be determined empirically, using the 50th percentile speed of low volume traffic (<1300 pc ph pl), or may be taken as either the posted limit or some reasonable lower figure. For freeways, use a base equal to 70 for urban and 75 for rural and adjustments for lane width, right shoulder lateral clearance, number of lanes, and interchange density.

The second category of delay studies is that encompassing traffic control devices, particularly traffic signals at intersections. In this case, delay may be considered as excess time over free-flow (green phase, unimpeded) similar to that above, or it may be further refined to establish percent of vehicles delayed, delay per delayed vehicle, delay per all vehicles, and stopped delay per stopped or all vehicles. This refinement of delay is useful in assessing the operation of a traffic control device.

5-5.02 Equipment

GPS based travel time systems are used frequently today.

The equipment required for delay studies depends upon the type of delay study being conducted. For freeway or other congestion delay type studies at least one vehicle and driver is required. In this case, the driver will need an audio tape recorder with a microphone input so that various checkpoints can be noted during the run. If a second person is used, that person can record the data directly onto a form so that the tape recorder is unnecessary. Intersection travel time/delay studies may be conducted similarly or may be conducted by stationary observers at the intersection. In this case the observers will need forms, clipboards and stopwatches to record the various counts and events.

5-5.03 Field Data Collection

5-5.03.01 Test Vehicle Method

To obtain travel time data, a test vehicle is usually operated within the traffic stream between check points along the route for which travel time information is required. The test vehicle is either operated as a "floating car" or at the "average speed." In the floating-car technique, the driver attempts to estimate the median speed by passing and being passed by an equal number of vehicles. In the average-speed technique, the driver operates the test vehicle at the speed perceived to be the average speed of other vehicles in the traffic stream. Tests have shown that some inaccuracies occur utilizing the floating-car technique, especially during periods of congested flow on multi-lane highways and on roads with very low traffic volumes. The average-speed technique has generally resulted in more representative test speeds.

The first task in obtaining travel time data is to identify check points along the route where travel time recordings will be entered on the worksheet.

Check points are located at intersections or railroad crossings or other easily-identified physical locations where speed changes are anticipated. Generally, check points in downtown areas should be about two or three blocks apart; in the downtown fringe, four to six blocks apart; and in other areas, eight to 12 blocks apart, depending upon the number of intersecting routes. The check points are indicated on a map and the distances between the check points are either obtained from true distance (TIS) files or from field measurements. Check points should also be referenced by reference post. The data are then transferred to the travel time data recording form.

Travel time test run is usually accomplished by an observer with two stopwatches. The observer starts one stopwatch at the beginning of the run and records the time at each check point along the route. The second stopwatch is utilized to determine the duration of any delays encountered along the route. The locations of delays are indicated on the recording form or noted on a voice recording.

5-5.03.02 Observed Vehicle Method

The observed vehicle method is used only to obtain total travel time information. Observers are stationed at check points where they record the time and the license number of each vehicle which passes an observation point. Later, the license plates are matched using the License Plate Match Computer Program and the total travel time between the check points is determined. Synchronized stopwatches and tape recorders are utilized in this procedure.

5-5.03.03 Moving Vehicle Method

The moving vehicle method presents an interesting way to compute volumes and average travel times in both directions by making only 6 runs (loops) in a test car. The features of interest of this method are:

1. It accurately estimates volume by direction for the entire route, in spite of intervening intersections, varying volume etc. This could be done by tubes, but only by setting counters in each section e.g. each block, and then weighting the average by section lengths.
2. It estimates average travel time not just of the test vehicle runs, but of all traffic.
3. The method applies best to city street type situations.
4. Because of the amount of data gathered during each run (total travel time, vehicles overtaken, vehicles which overtake, and opposing direction vehicles met), at least three persons will be required in the test vehicle. Data analysis is straight forward and given by example on Figures 5.10 and 5.11 and Form 5.J.

5-5.03.04 Intersection Study

The most common method of obtaining intersection delay, other than by a running vehicle method as above, is to station observers at the intersection. These observers collect:

1. The total number of vehicles stopped on the approach at regular, specified intervals - usually every 15 seconds unless the pre-timed cycle length is an even multiple of 15 seconds, in which case 13 seconds is used.
2. The total number of vehicles stopping and the total number not stopping.

In addition, other data is often collected during the delay study, such as movement counts, road and lane numbers and widths, and phase lengths. These are not required to compute delay, but are useful in assessing intersection performance.

5-5.04 Data Recording Forms

Several forms, both completed and blank, are shown in Figures 5.7 through 5.12 and Forms 5.F through 5.K, respectively. Note that the forms are self explanatory, and include notes regarding their use.

Travel time forms shown include provision for recording spot speeds (speedometer readings). Intersection delay forms include a worksheet area for computations.

5-5.05 Sample Size

1. **Test vehicle method**: at least 6 runs.

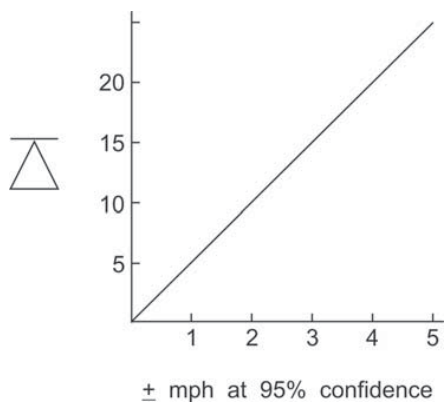
   This will provide a range for the computed mean speed shown on the graph below, where Δ is merely the average difference in speed from one run to the next for the six runs:

$$\bar{\Delta} = \frac{[S_1-S_2]+[S_2-S_3]+[S_3-S_4]+[S_4-S_5]+[S_5-S_6]}{5}$$

$$\bar{\Delta} = \sum_{i=1}^{5} \frac{[S_i-S_{i+1}]}{5}$$

where S_1 = speed for the 1st run, etc.

   The graph is as follows:



   Example: If the average difference in run speeds, is 15 mph, and the overall average speed has been computed as 41 mph, then (from the graph) the speed may be reported with an estimated precision of 41 mph ± 4 mph with 95% confidence.

2. **Observed Vehicle Method**: at least 30 matches. If only 6 matches were made, accuracy could be estimated as above. Since these are usually easier to collect in a short period of time than are actual travel time runs, it is wiser to collect a minimum of 30 samples to avoid small sample problems and to increase precision. A minimum of 30 samples will generally provide a precision of ± 2 mph with 95% confidence.

3. **Intersection Study**: Peak period or peak hour - gather data for 1 entire period.

   Notes: Samples should be gathered on typical days. In general, Monday AM and Friday PM peaks should be avoided. Days with inclement weather or on which significant crashes, stalls etc. occur should be avoided. If these occur during a study, the study must be partially or completely redone.

5-5.06 Computations

Computations are as outlined above, or as indicated on the data collection forms.

5-5.07 Uses of Travel Time/Delay Studies

This data has many uses, including:

1. Evaluation of level of service
2. Selection of traffic control devices
3. Before/after studies
4. Design of traffic control devices
5. Signal timing selection
6. Calculation of user costs
7. Identification of trends
8. Identification of sections needing geometric revision

5-6.00 VEHICLE OCCUPANCY

Vehicle occupancy refers to the number of persons in each vehicle, including the driver, and often excludes both buses and commercial trucks. This data is distinct from lane occupancy, described in section 5-106.00.

5-6.01 Equipment

The equipment required for data collection consists of pencil and paper, a watch, and a manual counter of at least six "banks." Usually a vehicle is needed to get to the site and to sit in during data collection. At very low volume sites, data can be collected using tally marks rather than counters, although even where volume is low counters are more convenient.

5-6.02 Field Data Collection

Data is collected manually by field observers with six bank counters. One "bank" (individual counter) is used for each of:

1. Vehicles with driver only
2. Vehicles with 2 persons
3. Vehicles with 3 persons
4. Vehicles with 4 persons
5. Trucks
6. Buses

The occupancy data collection form has columns for 5, 6 and 7 or more persons per vehicle as well. Since the number of vehicles with occupancies this high is usually small, these are collected by simple hand tally marks near these columns on the form. Cumulative totals are recorded on the form at 15 minute intervals for all data (counters are NOT rolled back to zero).

5-6.03 Data Recording FormS

Completed and blank data recording forms are shown in Figures 5.13 and Form 5.L, respectively.

5-6.04 Sample Size

For most locations data may be collected for one session during the time period under consideration e.g. peak hour. To find the differences shown in the table below with 95% confidence, the minimum sample size should be as follows:

to detect a difference in occupancy as small as	collect a sample size of
.01	19,208
.02	4,802
.03	2,134
.04	1,201
.05	768
.06	534
.07	392
.08	300
.09	237
.10	192

5-6.05 Computations

Computations are generally self-explanatory. The "bottom line" information usually includes the average number of persons per car, e.g. 1.21 persons/car, given to hundredths. Also often presented are percentages of persons in vehicles with one occupant, two occupants, three occupants etc. Note that this is different from the percentage of vehicles carrying one occupant, two occupants etc. Since occupancies tend to vary with time of day, the time period during which the study was conducted is also given.

5-6.06 Use of Vehicle Occupancies

Occupancy data are usually used to assess the impact of various geometric (e.g. the addition of a high occupancy vehicle, HOV, lane), control (e.g. the implementation of metering), or operational (e.g. the use of additional bus runs) changes. Occupancy data also reveals the total number of persons utilizing a facility, or a theoretical maximum people carrying capacity. Trends in vehicle occupancy are often caused by new HOV facilities, rideshare promotion, changes in gasoline prices, and changes in bus service.

5-7.00 LANE OCCUPANCY

Lane occupancy is the percentage of time a point on a lane is occupied (covered) by a vehicle. This is directly related to the density of traffic flow, and thus also to speed, level of service (LOS) etc.

5-7.01 Equipment

Occupancy data are usually collected using six by six sawn in loop detectors. Although these are not strictly point sampling devices, the percentage of time such a detector is occupied yields an adequate occupancy value. Occupancies could be obtained less directly from speeds, headways, densities, aerial photography etc. but this is rarely, if ever done.

5-7.02 Field Data Collection

Data collection is usually done by automated equipment. Field collection of volumes and speeds may be used to estimate occupancies, but is not generally done.

5-7.03 Data Recording Forms

Data is usually recorded by automated, computer equipment.

5-7.04 Sample Size

Occupancies are collected for the time period of interest (usually in 30 second, one minute or five minute intervals) and used or reported. Since they are usually used only in evaluating flow during that same period, the sample size of one is the entire population, and any error is a result of equipment error etc. rather than sample size considerations.

5-7.05 Computations

A relationship between density and occupancy is approximated by:

Density = 2.5 veh/lane mile x % occupancy

where occupancy is given in percent and density in vehicles/lane mile.

5-7.06 Uses of Lane Occupancies

Occupancies are used primarily to assess traffic flow during real time traffic management. This data is used as input into computer algorithms which control changeable message signing, metering rates, and traffic flow information devices.

Occupancies are also used to evaluate whether flow is at capacity, to assess changes in flow conditions, and to evaluate the impact of crashes or stalls on traffic flow.

5-8.00 VEHICLE DENSITY

Vehicle density, mentioned above as being indirectly obtainable from lane occupancy information, is occasionally obtained directly. Information is usually presented in units of vehicles per mile or vehicles per lane mile (VPLM). According to the 2000 "Highway Capacity Manual", density is the primary measure use to calculate the Level of Service for basic freeway segments. The Level of Service thresholds are summarized below:

LEVEL OF SERVICE DENSITY RANGE

	(pc/mi/ln)
A	0 - 11
B	11 - 18
C	18 - 26
D	26 - 35
E	35 - 45
F	>45

Example for Level of Service "F"
(5,280 ft/mi) / (45 pc/mi/ln) = 117 ft/pc
At 60 mph (88 ft/sec), this is 1.3 second headway between veh.

5-8.01 Equipment

Density may be estimated from lane occupancy data, using the same collection equipment (5-6.01). Other methods of estimating the number of vehicles on a section include aerial photography, which requires the use of an airplane or helicopter as well as appropriate photographic equipment. Although this is a direct, accurate method of determining instantaneous vehicle density, it is also complex, costly and in most cases of more theoretical than practical interest.

5-8.02 Field Data Collection

See section 5-7.02

5-8.03 Data Recording Forms

No special forms are required. If density is estimated by counting volume into and out of a section of known initial state (i.e. the number of vehicles on the section at the start of the study is known or assumed), then volume counting forms may be used.

5-8.04 Sample Size

Usually the density is averaged for the time period in question, similar to occupancy data. Due to seasonal variation, trends, variation in the time of occurrence of peak density etc. precise long term densities are not normally given, or if given, are presented without confidence intervals. If densities are used for before/after studies (this is rare), sample sizes may be established based on appropriate variances.

5-8.05 Computations

See Section 5-7.05

5-8.06 Uses of Vehicle Densities

Vehicle densities are used to assess the quality of flow on a roadway section and are the primary measure of Level of Service for freeway segments. Most uses are theoretical rather than practical.

5-9.00 QUEUE STUDIES

5-9.01 Types of Queue Studies

Queue studies are of two primary types, related to two general ways of defining a queue:

1. A line of stopped (or nearly stopped) vehicles created by some traffic control device, notably a signal or a stop sign, or due to some movement restriction, for example a queue buildup behind a vehicle waiting for a gap in order to make a left turn.
2. A number of cars moving as a group or definable platoon moving at a speed less than free flow speed due to congestion or some particular traffic stream and/or roadway anomaly (e.g. congestion induced shock waves, queues formed upstream of bumps, potholes, lane drops, stalled vehicles etc.).

This section is concerned only with the first type of queue, which may be simply called a waiting line of stopped vehicles. The second type of queue is used far less frequently and will not be considered. For a discussion of this second type, see references.

5-9.02 Equipment

Collection equipment for queues usually includes a stopwatch and a clipboard with appropriate forms. Special equipment such as delay meters, intersection counting boards or programmed hand held computers may be used, especially when delay, capacity or other characteristics are the end products desired rather than queue lengths themselves. In this case the use of electronic equipment may significantly reduce data reduction person-hours.

5-9.03 Field Data Collection

Data is usually collected by stationing an observer within view of the queue, and having this observer record queue lengths at set intervals, see Form 5.M. For intersection studies, an interval of 15 seconds is usually used, as long as the cycle is not an even multiple of this, in which case another interval, usually 13 seconds, would be used. Other studies often use 30 second intervals, which allows more accurate counting of long queues. For this reason, a longer interval may also be used for intersection studies if the queue is difficult to count at shorter intervals. Another method of counting very long queues is to count the number of vehicles back to a known point, and then count only the remainder or "tail" at each interval thereafter when vehicles are backed up beyond the known point. Later the length of the tail and the vehicles back to the known point are summed to find the actual queue length. This system is particularly useful where the queue is constant, such as at ramp meters.

5-9.04 Data Recording Forms

For delay studies at intersections, the forms presented in section 5-5.04 are used to record queue lengths. A more general queue length form is given in Figure 5.12. If all that is needed is maximum queue length, which is sometimes the case, no specialized form is needed.

5-9.05 Sample Size

For delay at intersection studies, see section 5-5.05. Other queue studies usually require collecting queues at 30 second intervals over the time period in question on three separate occasions. The primary reason for collecting data three times is to ensure that data has not been collected on an anomalous day. If it is certain that a day is "typical," queues may be collected only once.

5-9.06 Computations

Maximum queue length (Maximum queue): This is taken directly from data recording forms.

Average queue length: This is the mean of all measured queues (Sum of all lengths ÷ number of queues counted).

Median queue: From a driver's standpoint, this is more meaningful than the mean. The median queue is the queue with 50% of queues longer than it. Easily obtained by writing queue lengths in order by length then by observation. If the number of queue lengths is odd, take the middle length; if the number of queue lengths is even, take average of middle two lengths. Also called 50th percentile queue.

Queue delay: See section 5-5.03.04

Note that all of the above report queue lengths in terms of numbers of vehicles. For some special purposes queue lengths may be reported in terms of meters or delay, although these are usually derived rather than directly collected.

5-9.07 Uses of Queue Data

In addition to use in delay studies assessing the performance of traffic signals, ramp meters or other traffic control devices, queues may be used directly to quickly evaluate timing plans, the quality of traffic flow, or the need for additional facilities and appurtenances.

5-10.00 VEHICLE CLASSIFICATION

Vehicle classification consists, in its most basic form, of determining the percentages of automobiles and trucks in the traffic stream at a particular location. Often an additional category of buses is used. Further, the category of trucks is sometimes subdivided into semi and unibody styles, or into subdivisions based on length or number of axles. Other categories sometimes considered separately include motorcycles, vans and pickups, taxis, and recreational vehicles (RVs). What categories are utilized depends upon the purpose of the study, the level of the category in the traffic stream, and the categories used in previous studies which will be used for comparison. Also, some categories are avoided due to the difficulty of collecting the data. Trucks by length in meters is an example of this, as are categories based on vehicle ownership.

5-10.01 Regularly Conducted Counts

Vehicle classification counts are conducted at numerous stations throughout the State by the TDA Section. Information regarding the classification categories used and sites available may be obtained from that office.

5-10.02 Equipment Used

Most special purpose classification counts are done manually with no more than a multiple bank mechanical counter and a data recording form. Occasionally the data is first recorded on film or video tape and then the data is extracted. This may allow filming during unusual hours or for long periods while confining data extraction to normal working hours. Also, simple data may be gathered from tapes or film played back at fast speed, reducing actual collection time. Some portable electronic equipment is also available to do classification counts, usually based on axle spacings. This equipment can greatly simplify collecting large samples, but may restrict the classification categories that may be used, e.g. the equipment will not distinguish between buses, RVs, and trucks, between private and commercial vehicles etc.

5-10.03 Field Data Collection

Simple classification data is sometimes a by-product of other studies. For instance, collection of vehicle occupancies generally includes a separate tally of trucks and buses (5-6.03). Field collection is usually done with tally marks on a form (5-10.04) or with counters sufficient to accumulate each of the classification categories desired.

One of the common difficulties involved with field data collection is defining categories clearly enough so that the field data collector can count each category confidently. Typical problems with categories include: In what category is a motorcycle, taxi, airport limousine or vanpool? Is a delivery van, a van or a truck? Are pickups with crew cabs and six tires pickups or trucks? What about recreational vehicles or cars pulling boats, trailers or campers? What is a semi cab without a trailer?

If the study has separate categories for each of these vehicles, the problem disappears. This is usually not the case. There may be only two to five categories, so that study planners must decide how to handle questionable cases. Occupancy studies done by the RTMC often involve only three categories: automobiles, trucks, and buses. In this case motorcycles are classified as cars, taxis and limousines as buses, van pools as cars, delivery vans, six wheel pickups, RV's and cars towing trailers or boats as trucks etc.

The way the categories are defined depends upon which categories are used and the purpose of the study. Must the study differentiate between commercial and private vans? Is motorcycle usage being studied? Once the purpose of the study is clearly defined, the categories must be selected and defined so that appropriate data is collected. Both the study purpose and the definitions must be passed on to the field data collectors to allow them to make quick, appropriate real-time decisions. After the first session of data collection, field notes and comments should be reviewed to allow "fine tuning" of the categories and definitions.

5-10.04 Data Recording Forms

Typical forms are included as Figures 5.13 and Form 5.N. Note that often special purpose studies will require the creation of new forms for data collection.

5-10.05 Sample Size

In most cases extreme accuracy is not needed for classification studies. The usual procedure is to collect classification data for one session during the time period of interest e.g. peak hour.

5-10.06 Computations

Usually computations consist of simply figuring the percent of each category of vehicle for the time period studied. In low volume situations, the classification count may include all vehicles, in which case the number of vehicles in each category is also immediately available. In other cases, the percentages obtained may be applied to separately collected volumes in order to estimate the number of vehicles in each category.

5-10.07 Uses of Vehicle Classifications

Vehicle classifications are used in capacity computations, in assessing the impact of traffic regulations or controls not directed at all types of vehicles, in some economic analysis of travel or delay, and to evaluate the people moving effectiveness of HOV and other facilities.

5-11.00 LICENSE PLATE CHECKS

5-11.01 Equipment

In all but the lowest volume situations, it is simplest to read license numbers into a cassette recorder. Microphones with integral on/off switches are easiest to use and conserve tape. In the office the data is recorded onto a computer coding form. If the license numbers are being used for simple matching, as in an origin destination (O-D) study, the data can be evaluated by hand, by PC using an ad hoc program, or by programs available at IMB (License plate matching system, DTTC 6110 and DTTC 6210).

If the license plates are being recorded for the sake of obtaining address labels, as for mail-out questionnaires, the numbers, recorded on general purpose coding forms should be sent to the Department of Public Safety for processing.

5-11.02 Field Data Collection

The observer should be stationed as near the roadway as possible, at a point where the traffic is slow or stopping. Because of dirt and salt, the winter months are usually bad for collecting plate numbers, although an adequate sample may be taken. The observer should face oncoming traffic to read plates. Plate numbers are read into the cassette recorder. When an O-D Study is being conducted, begin and end data collection times for various observers must be coordinated to account for the distance between observers, the traffic already in the system, and the desired time interval.

5-11.03 Data Recording Forms

No special forms are necessary.

1.1.1 Mapping and Utilities

1.1.1.1 Aerial Photography and Photogrammetrics

Aerial photography and photogrammetrics are used to begin the three-dimensional location data collection required for transportation projects. Flights are made in the spring and fall over specific corridors to routinely update the Department's records and to address the aerial photography needs of specific projects.

Survey data can be gathered for individual stand-alone traffic control signal system or interconnect projects without the use of aerial photography and photogrammetrics. It is more effective, however, for the Department to make use of aerial photography and photogrammetrics to build a complete database of survey information for the area that will benefit the individual traffic control signal system or interconnect project and any future projects in the area. Therefore, standalone signal or interconnect systems which have letting dates 2.5 or more years in the future should include aerial photography and photogrammetric activities. To begin these activities, contact the surveys office to ascertain needs and limits of the aerial photography flight and target placement.

1.1.1.2 Utility Information

By law, utility locations must be checked within 90 days of the project turn in.

For stand-alone traffic control signal system or interconnect projects, the signal designer is responsible for completing the utility plan sheets. Major activities to accomplish this requirement include:

- The designer contacts Gopher State One Call for a utility list for the project limits and checks this against any survey location information.
- The designer creates a preliminary utility plan sheet with graphics and a tabulation identifying owner, type of utility, any work to be done to the utility, location information and any remarks. A standard note such as, "It shall be the contractor's responsibility to utilize the Gopher One Call Excavation Notice System (phone 651-454-0002), required by MN Statute 216D, for all utility locations" should be included on all utility plan sheets (refer to the web site).
- The designer contacts each utility by letter with an attachment of the preliminary utility plan sheet to allow utility to confirm/correct the utility data.
- The designer contacts the Permits office within the 90-day limit to check for any recent utility installations or relocations since the time that the initial utility location data was collected.
- The project manager completes the compliance checklist and submits it with the project package for each state let project.

If the traffic control signal system project is part of a larger roadway project, than the traffic control signal system project manager and the roadway project manager should work together to include all utility information necessary within the roadway utility information sheets. The traffic control signal system plan should then reference the roadway utility sheets.

Utility Quality Level is a professional opinion about the quality and reliability of utility information. There are four levels of utility quality information, ranging from the most precise and reliable, level A, to the least precise and reliable, level D. The utility quality level must be determined in accordance with guidelines established by the Construction Institute of the American Society of Civil Engineers in document CI/ASCE 38-02 entitled "Standard Guidelines for the Collection and Depiction of Existing Subsurface Utility Data."

According to Minnesota Statutes, section 216D.04, subdivision 1a, all plans for projects with excavation must depict the utility quality level of the utility information. Unless there is proof that the utility

information in the plan is more accurate, MnDOT assumes that it is Utility Quality Level D. The project manager must use the following note, filling in the appropriate utility quality level, on the utility tabulation sheets for projects involving excavation:

> *The subsurface utility information in this plan is utility quality level ___. This utility quality level was determined according to the guidelines of CI/ASCE 38- 02, entitled "Standard Guidelines for the Collection and Depiction of Existing Subsurface Utility Data."*

The Minnesota statute on utilities can be found at the following web site:

http://www.revisor.leg.state.mn.us/stats/216D/04.html

Exhibit 1-1 Minnesota Statures Website

1.1.1.3 Survey Requests

The traffic control signal system designer or project manager (PM) is responsible for survey requests for all signal projects not involving road work. If road work is included as part of the project, the designer or PM should work with the road designer for any survey needs since the road designer should be kept well informed of all survey or utility information being gathered for the project.

To facilitate construction activities such as staking and utility location/relocation, in addition to improving the ability to interact with Geographic Information System (GIS) databases, coordinate-correct and tabulated signal plans are required.

MnDOT survey requests may use the information request forms created by the surveys office. The MnDOT Metro Survey Data Request Form is shown on the following page. For internal MnDOT projects, the form can be found at the following link:

http://ihub.metrosurveys/electronic_survey_data_request_form.html

METRO UTILITY REQUEST FORM

Today's Date _____ Date Required _____ Let Date _____

Requested By _____ Telephone _____

S.P. _____ T.H. _____ Charge ID/Job No. _____

Utility Information

Work requested: (Including Limits)

Preliminary Phase:

Utility Company Maps ☐

Field Locates ☐

Field Locates with Elevation ☐

Design Phase:

Field Review ☐

Information Meeting (Please Provide Attachment) ☐

Design Utility Meeting ☐

Utility Design Change Meeting ☐

Utility Coordination Follow up Meeting ☐

Utility Verification:

GSOC ☐

Letters ☐

Draw a sketch of the area or attach an electronic map.

Please note: Marking Instructions, See Attached

Project Manager: _____

Work Started: _____ Work Completed: _____

Submit your request to Metro Utilities and the person requesting this information will be contacted.

1.2 SIGNAL JUSTIFICATION

1.2.1 Intersection Control Evaluation

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.

The goal of ICE is to select the optimal control for an intersection based on an objective analysis for the existing conditions and future needs. ICE would replace the current process.

In order to determine the optimal intersection control strategy, the overall design of the intersection must be considered. The flexibility of significant change in intersection design will largely be decided by the scope and location of the project. Some general objectives for good intersection design that should be considered are:

- Provide adequate sight distance
- Minimize points of conflict
- Simplify conflict areas
- Limit conflict frequency
- Minimize the severity of conflicts
- Minimize delay
- Provide acceptable capacity

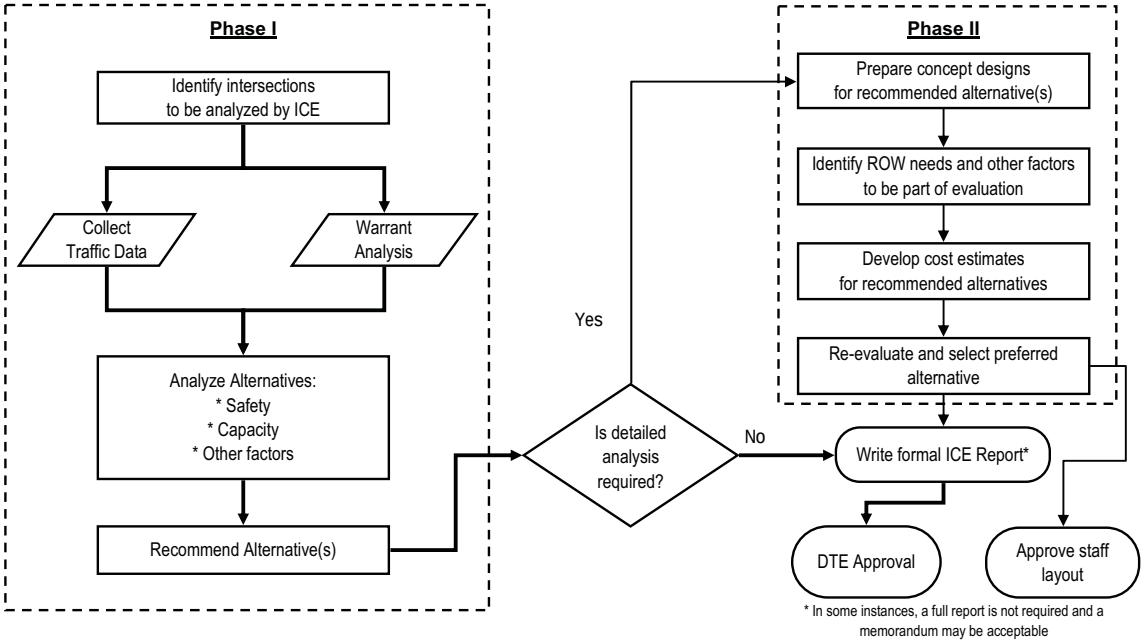
The purpose of the ICE report is to document all of the analysis (technical, financial, political) that went into determining the recommended alternative. Early decisions help limit scope creep. The ICE process will help collaborate with local agencies and considers all options on an equal basis.

The information following this sheet is a handout taken from the Intersection Capacity Control (ICE) Course Manual. This Manual was not currently on the website at the time of publication. But, it will be placed on the OTST website for future downloads.

3. THE ICE PROCESS

The process needed to complete an ICE is highly dependent on two factors. These factors will influence how much effort is involved in completing the study, who is involved in each stage of the study and for what they are accountable. Figure 15 illustrates the ICE process.

Figure 15 – The ICE Process



As shown in Figure 15, the ICE is conducted in two phases. The first phase is usually done very early in the project development process, oftentimes, before a project is programmed. This could occur during planning or corridor studies but no later than the scoping portion of an improvement project. The purpose of the first phase is to recommend one or more traffic control strategies for further development. Under normal circumstances, an ICE would be needed if a safety or capacity problem has been identified, that has an associated infrastructure improvement. An ICE is also required for a new intersection being constructed due to development or expansion of the highway system. The second phase, Alternative Selection, involves other functional units (Design, Land Management, etc) and parallels the process of developing an approved preliminary layout. Based on a number of factors the recommended traffic control is determined in this phase.

Avoid overanalyzing a location. If a decision has been made or one traffic control type will be the choice, document the decision making process and include in a short memo or basic report. It still may be necessary to gather traffic data, conduct a warrant analysis and complete a safety and capacity analysis.

A decision may be reached after Phase 1. It may still be necessary to develop preliminary layouts, cost estimates and other project development tasks, but an ICE report can be completed at this time. However, if the project development process negates what has occurred in Phase 1, it will be necessary to revise the report.

For larger projects in areas where traffic volumes may increase on the local system as well as the arterial, careful consideration should be taken to determine if an ICE is necessary. Relying on future

traffic projections, in which traffic volume warrants are barely met, should not be a requirement to perform an ICE. Generally speaking, if warrants are unlikely to be met within a 5 year time frame, an ICE is unnecessary.

3.1 Phase I – Scoping

The project can originate within Mn/DOT or from an outside jurisdiction. If the project originates from an outside jurisdiction, that entity is responsible for conducting the ICE. It is imperative that Mn/DOT Traffic units be involved early in the process to ensure that the analysis will be accepted and approved. Within Mn/DOT, projects can originate within or outside of Traffic Engineering. For those projects originating within Traffic Engineering, all of the responsibilities in completing the ICE will be coordinated through that unit. For all other projects, Traffic Engineering should be consulted early in the project development process to ensure that an ICE can be completed in a timely manner. For all ICEs completed by outside jurisdictions or consultants, Traffic Engineering is responsible for review and approval.

3.1.1 Identify Intersections

Generally, smaller projects will require less analysis and therefore less documentation. Preservation projects (e.g. signal rebuilds) will require minimal analysis. However, a memo/letter must be submitted for approval. The document should state rationale for the work being done and why other types of traffic control are not being considered. Stand-alone intersections will require safety and capacity analyses as well as documentation of other impacts (cost, ROW, political concerns, etc). The amount of analysis will depend on each project's location and scope. Intersections, which are a part of larger projects, will probably require significant analysis and documentation. Coordination with Traffic Engineering on these projects is important. Making decisions on traffic control earlier in the project development process will improve the quality of the design and minimize conflicts with stakeholders.

3.1.2 Collect Data

For completion of the report, the following data may be required. Some of these requirements can be waived depending on existing conditions and the available improvement alternatives. The District Traffic Engineer must be contacted to approve a change in requirements.

3.1.2.1 Traffic Volumes

- Hourly intersection approach counts (must be less than 2 years old) for 48 hours
- Turning movement counts for the AM and PM peak periods (3 hours each and less than 2 years old)
- Future intersection approach volumes (only needed if Warrant is unmet in existing time period)
- Future turning movement volumes for the AM and PM peak hours using pre- approved growth rates or future modeling parameters
- Pedestrian and bicycle volumes by approach, if applicable

Discuss with the District Traffic Engineer the traffic volume requirements for the particular study.

3.1.2.2 Crash Data

- Crash data for the last three full calendar years (Must be obtained from the Mn/DOT TIS database).
- Crash diagrams must be included in the report. Rationale for crash reductions based on each alternative must be documented. Crash listings should be included in an appendix.

3.1.2.3 Existing Geometrics

- The existing geometrics of the intersection being considered for improvement must be documented. It is preferable to provide a layout or graphical display of the intersections showing lane configurations with existing striping, lane widths, parking lanes, shoulders and/or curb treatments, medians, pedestrian and bicycle facilities, right of way limits and access driveways or adjacent roadways for all approaches. The posted speed limit and the current traffic control of each roadway must also be shown or stated. Adjacent structures, overhead utilities, and vaults should also be outlined such as buildings, bridges, box culverts, power poles, etc.
- A larger scale map showing the intersection in relationship to parallel roadways and its relationship (including distances) to other access points along the corridor is also required.
- The locations of schools or other significant land uses, which may require more specialized treatment for pedestrians or vehicles, should be documented, if applicable.
- Geographic features must be shown if they will influence the selection of an alternative, such as severe grades, wetlands, parkland, etc.

3.1.2.4 Proposed Geometrics/Traffic Control Alternative

A layout or conceptual plan showing the proposed geometrics for the recommended traffic control alternative must be included. An electronic copy of the design is preferred and may be required depending on the intersection alternative. The plan should document all changes from the existing conditions.

3.1.2.5 Capacity Analysis

A summary table of delays for all movements, approaches and overall intersection delay must be provided for AM and PM peak hours, both existing and future conditions, for each alternative analyzed. Software output should be included in an appendix. An electronic copy of the analysis is preferred.

Additional data may be necessary depending on the location and alternatives analyzed. These could include – community considerations (need for parking, sidewalks, bike lanes, etc); future development plans, which may influence access; types of vehicles intersecting roadway, if unusual; transit routes and frequency; compatibility with corridor plans or local transportation plans; Interregional Corridor performance and political considerations.

3.1.3 Perform Warrant Analysis & Justification

In order for the engineer to determine if any traffic control is necessary at an intersection, data must be examined to determine if a “Warrant” is met for the particular intersection control alternative. Even if a “Warrant” is met, it may not be the correct action to take for a given situation. The engineer must determine if the treatment is “Justified.” The “Warrant” and “Justification” process is detailed below.

3.1.3.1 Warrants

Be sure to use the latest version of the traffic signal warrants found in the MN MUTCD.

The Minnesota Manual on Uniform Traffic Control Devices (MN MUTCD) contains warrants for All-way Stops and for Traffic Signals. Generally speaking, warrants are met if the amount of vehicular traffic, crashes, or pedestrians is significant enough to meet minimum levels. These levels are based on research, which documented the conditions where additional traffic control was considered. Information needed to determine if a warrant is met is contained in the MN MUTCD and the Mn/DOT Traffic Engineering Manual.

A Mn/DOT District Traffic Engineer will interpret this information to determine which warrants apply to a given location. For example, refer to the Metro District’s practice on traffic signal justification.

Traffic volumes must be obtained. For most cases existing volumes are preferred. However, future anticipated volumes may be used if development is imminent. For new roadways projections must be used. Confer with the District Traffic Engineer on which warrant will be allowed.

Warrants are commonly used to determine if either an all-way stop control or a traffic signal should be considered for a location. Roundabouts are considered to be warranted if traffic volumes meet the criteria for either all-way stops or traffic signals.

However, site-specific safety issues may warrant the installation of a traffic control device (e.g. a roundabout) where traffic volume warrants are not met. Special considerations to install a traffic control device should be taken at any intersection where "typical" warrants are not met but safety issues are present. The District Traffic Engineer must be consulted when these conditions are present for guidance on whether additional traffic control will be considered.

3.1.3.2 Justification

Even if an intersection meets a warrant for traffic control, that treatment may not be justified. The justification process requires engineering judgment. Whether an intersection justifies a particular type of intersection control is based upon a number of factors. The ICE report should document these factors to support the alternative or not. These factors should include, but are not limited to, the following:

- Existing safety and congestion issues
- Plans for the roadway based on an adopted corridor study
- The spacing of nearby intersections or driveways and how they conform to adopted access management guidelines
- The environment in the corridor
- Future anticipated traffic volumes
- The distance to the nearest traffic controlled intersections
- The amount of turning traffic
- The breakdown and percentage of types of vehicles
- The amounts of non-motorized traffic
- Sight distance
- Available right of way
- Available funds for construction
- Support of the local users and local agencies

3.1.4 Metro Traffic Signal Justification Methodology

The Mn/DOT Metro division has developed a justification process that is discussed in this section. This is to be used for all districts except when the particular district has a written methodology for signal justification. The Metro process looks a particular warrants (not all eight) and mitigating factors. In addition, this process defines how to handle right turn movements at the intersection.

The decision to install a traffic signal at a trunk highway intersection in the Metro District is determined by the Program Support Unit of the Traffic Engineering Section. The installation of the signal must be justified through an engineering study. Contained in this section of the ICE Manual is the current methodology in determining if a signal installation is justified **in the Metro District**. If a location is justified, it does not necessarily mean that a signal will be programmed or the installation will occur immediately. Funding must be available and the location must be a higher priority than other safety needs.

Qualifying Criteria

For a specific intersection to be considered for a traffic signal installation one of the following criteria must be met.

1. The intersection meets Warrant 1A, 1B or 7 of the current MN MUTCD.
2. Current traffic volumes do not meet Warrant 1A or 1B, but development in the area will occur such that the warrants will be met in a reasonable period of time and state funds are not used for construction.

Mitigating Factors

As part of the engineering study, the following factors should be considered in determining if a signal installation is justified.

1. Access spacing guidelines. Is spacing between signals on the mainline adequate? Is spacing between all nearby public and private access points adequate?
2. Is the installation of a signal at this location consistent with an adopted access management plan for the roadway?
3. Lane geometrics. Metro requires one lane of approach for each traffic movement for all directions of travel. For a typical four-legged intersection, a minimum of three lanes would be required for each approach, including the minor legs. (Metro will consider 2 lanes of approach from the minor legs under some conditions) Does the proposed layout provide minimal geometrics?
4. Each intersection should be modeled using acceptable simulation software in order to demonstrate acceptable traffic operations for opening day and for a reasonable period into the future (preferably 20 years). Adjacent intersections may be required to be included depending on spacing and other considerations. Will the proposed geometrics provide enough capacity for acceptable operations?
5. Is installation of a traffic signal the only solution or are better alternatives available?
6. Will the intersection be safer after the signal is installed?

Warrants Use the warrants as detailed in the latest version of the MN MUTCD

<u>Warrant 1 – Eight Hour Vehicular Volume</u>

If the intersection meets either Condition A (Minimum Vehicular Volume) or Condition B (Interruption of Continuous Traffic), then the intersection is considered to have met this warrant. Meeting a warrant does not necessarily mean the location is justified for a signal. Engineering judgment is required for that step and all mitigating factors must be considered.

Current traffic volumes must be collected to analyze the volume warrants. It is desirable to collect a 48-hour approach count AND a 6-hour turning movement count (3 in each of the peak periods) for

each intersection. These counts should be done Tuesday, Wednesday or Thursday to accurately depict typical weekday traffic volumes.

Right turning traffic from the minor leg is usually not included in the warrant analysis. The rationale for this practice is these movements are usually made relatively easily, have minimal conflicts and therefore do not require a traffic signal to minimize delay or improve safety. After the traffic volume data is collected, the percentage of right turning vehicles from the minor legs is determined based upon the turning movement count. The right turn percentage is removed from the approach counts to determine the volume to be used in the warrant analysis. (Typically it is assumed that the percentage of right turns during the two peak periods (6 hours) is representative of the entire day.)

In the event that there is a significant amount of right turning traffic and conflicting traffic, 50% of the right turns can be added back into the approach counts. If the right turning volume exceeds 70% of its potential capacity (see Table 2) for any hour for each approach, 50% of the right turning volume for all hours should be added back in. To use the table determine the conflicting flow rate for each minor approach. The rate will be the conflicting mainline approach traffic, in the lane the right turning vehicles are merging into (For multiple through lane roadways divide the volumes evenly across each lane). Utilizing the correct table (2 lane or 4 lane) the user must determine if the right turn volume exceeds the 70% potential capacity. (The capacity of the minor leg right turning volume is calculated based on procedures documented in the Highway Capacity Manual.)

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 (Table 3)
2. Condition A or B is met for at least 8 hours a day as shown on the 70% column (Table 3) 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.

Table 2 – Right Turn Capacity

Potential Capacity for Two-Lane Streets			Potential Capacity for Four-Lane Streets		
Conflicting Flow Rate	Potential Capacity	70% of Potential Capacity	Conflicting Flow Rate	Potential Capacity	70% of Potential Capacity
0.01	1090	760	0.01	1090	760
100	960	670	100	940	660
200	850	600	200	810	570
300	740	520	300	700	490
400	650	460	400	610	430
500	570	400	500	520	360
600	500	350	600	450	320
700	440	310	700	390	270
800	390	270	800	330	230
900	340	240	900	290	200
1000	300	210	1000	250	180
1100	260	180	1100	210	150
1200	230	160	1200	180	130
1300	200	140	1300	150	110
1400	170	120	1400	130	90
1500	150	110	1500	110	80
1600	130	90	1600	100	70
1700	120	80	1700	80	60
1800	100	70	1800	70	50
1900	90	60	1900	60	40
2000	80	60	2000	50	40
2100	70	50	2100	40	30
2200	60	40	2200	40	30
2300	50	40	2300	30	20
2400	40	30	2400	30	20
2500	40	30	2500	20	10
2600	30	20	2600	20	10
2700	30	20	2700	20	10
2800	20	10	2800	10	10
2900	20	10	2900	10	10
3000	20	10	3000	10	10

Table 3 – Warrant 1

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

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 with Warrant 7, Crash Experience.

To determine the number of lanes to use in Table 2, the proposed lane geometrics must be used. Right turn lanes are not counted, but in most cases the row referring to two or more for both the major street and the minor street will be used. Left turn lanes are included in the total number of lanes.

Warrant 7 – Crash Experience

To meet this warrant two conditions must be met:

1. Five or more reported correctible crashes have occurred within any twelve-month period. Data can be used for the last 3 reported calendar years. Correctable crashes are those involving left turning movements from either the mainline or the minor street and through movements from the minor leg. These are typically, right angle and left turn related crashes. All other crashes are not considered (rear ends, run off road, etc...).
2. The eight-hour vehicular warrant described above must be met for the 80% column for either Condition A or Condition B. The treatment of traffic volumes is the same as described above.

If you have questions, please contact Lars Impola of Metro District Traffic – Program Support.

3.1.5 Analyze Alternatives

3.1.5.1 Crash Evaluation

Depending on the existing crash pattern at an intersection, different traffic control treatments will have predictable impacts on these patterns. For each alternative, an estimate of crash frequency should be completed. There are a number of methods for this task. The goal should be to determine the impacts of each alternative as accurately as feasible. The utilization of crash reduction factors, crash rates, comparisons to similar intersections, research and logic can all be used, but should be tempered by common sense. Consultation with the District Traffic Engineer is recommended on the most recent acceptable methods for a given treatment and location. [Note: Crash reduction factors are currently being developed for the ICE method. Be sure to check with the DTE to determine if these rates are available.]

Existing crash records should be obtained and shown in the report as stated in the Tech Memo.

For each alternative an estimate of future crashes should be obtained. It is suggested that this analysis utilize crash rates to keep it simple. If desired, a more thorough crash reduction methodology can be used. A table of average crash rates for each alternative has been developed and will be updated and revised periodically. Refer to the Traffic Safety Fundamentals Handbook available at http://www.dot.state.mn.us/trafficeng/otepubl/fundamentals/safetyfundamentals.pdf.

A comparison of anticipated total crashes and severe crashes should be documented for a target year. It is unnecessary to compute crash reductions per year and crash cost. Currently, this additional data is considered to be unnecessary.

3.1.5.2 Capacity Evaluation

To evaluate the capacity and level of service of a particular intersection it is important to begin with basic traffic data:

1. Existing AM and PM turning volumes
2. Design year AM and PM turning volumes (Compare design year flows with the existing flows and check out any anomalies. It is critical that the design year flows do not exceed the capacity of the surrounding network.)
3. Design vehicle
4. Base Plan with defined horizontal, vertical, and site constraints
5. Existing and design year pedestrian and bicycle volumes

For Phase I, Scoping, the capacity analysis will vary depending on the type of project. The primary goal in Phase I is to determine if the alternative will operate at an acceptable level of service. A secondary goal is to provide a gross comparison between alternatives. Consult with the District's Traffic Engineering unit on acceptable procedures for this analysis. In all cases, analysis with acceptable capacity analysis software will meet this condition. Simplified methods are being explored and developed.

<u>Year of analysis</u>

20 year projects are the default for this type of analysis, however, due to the variability in accuracy of traffic projections, shorter time frames should be strongly considered in many instances. If total development is expected to occur within 5 years, 5 years should be the target year for analysis. If the capacity analysis appears to highlight near failures within this timeframe, future projections should be analyzed.

<u>Choice of models</u>

Generally speaking, avoiding the use of VISSIM should always be the rule. If analysis of individual intersections indicates no potential for queues impacting adjacent intersections, there is no need to conduct a VISSIM analysis, no matter how many intersections are analyzed or their lack of adequate spacing. However, if the opposite is true, first optimize the individual intersection analysis or increase geometric options which increase capacity and only if that fails should VISSIM be used.

The primary goal of this exercise is to first – insure that each intersection will operate acceptably for each type of traffic control and second – to provide a gross level of comparison between options.

3.1.5.3 Additional Factors

Right of Way Impacts and Project Cost

Each alternative that is recommended to proceed to Phase II, Alternative Selection, will have concept drawings prepared for the purposes of determining right of way impacts as well as construction costs. The level of detail in the design will be determined by the project manager depending on the location, type of intersection alternative, and other issues. The goal of this step is to have reasonable assurance that all right of way impacts are determined and an accurate cost estimate is obtained.

Political/Public Considerations

A large factor in the decision of intersection control is driver expectancy. Each feasible alternative should be assessed for driver expectations and political viability. In Phase II, typically the local jurisdictions and other important stakeholders would be consulted to determine the acceptability of an alternative. If the result was negative, this alternative should be dropped from further consideration, especially if cost participation is required. During Phase II, the degree of public involvement in the discussion of alternatives must be determined by the project manager in consultation with local stakeholders and Mn/DOT functional units. In any event, stakeholders should be aware of the technical merits of each alternative.

Other Considerations

Unconventional Intersection Geometry Evaluation. Conventional forms of traffic control are often less efficient at intersections with a difficult skew angle, significant offset, odd number of approaches, or close spacing to other intersections. Roundabouts may be better suited for such intersections, because they do not require complicated signing or signal phasing. Their ability to accommodate high turning volumes makes them especially effective at “Y” or “T” junctions. Roundabouts may also be useful in eliminating a pair of closely spaced intersections by combining them to form a multi-legged roundabout. Intersection sight distance for roundabouts are significantly less demanding than for other conventional intersection treatments.

Terrain. Traffic signals and roundabouts typically should be constructed on relatively level or rolling terrain. For traffic signals, the maximum approach grade will vary depending on the ability for approaching traffic to see the signal heads and the impact of the approach grade on the operations of the predominate vehicle type. For roundabouts, the maximum approach grade should be 4% within the required Stopping Sight Distance (SSD) of the yield line. Grades approaching these values and steeper terrain may require greater transitions to provide an appropriate level area or plateau for the intersection.

Adjacent Intersections and Coordinated Signal Systems. The spacing of intersections along a highway corridor should be consistent with the spacing of primary full-movement intersections as shown in the Mn/DOT Access Management Policy. District Traffic Engineering may allow intersection spacing exceptions for roundabouts based on justifiable merits on a case-by-case basis. Generally speaking, positioning a roundabout within a coordinated signal system or very near to an adjacent signal is not preferred, however, under some circumstances it may be an acceptable option. A comprehensive traffic analysis is needed to determine if it is appropriate to locate a roundabout within a coordinated signal network.

System Consistency. On Interregional Corridors (IRC) or other highways where a corridor study has previously been prepared, any alternative should address the impact on the Interregional Corridor performance or should be compared to the recommendations of the corridor study. If the alternative adversely influences the performance of the IRC or it is not consistent with the corridor study, justification for the alternative should be included.

Pedestrian and/or Bicycle Issues. Accommodating non-motorized users is a Mn/DOT priority. Depending on the volume of users and the sensitivity of the location, one alternative may be preferred to another. Additionally, if large numbers of non-motorized users are anticipated, they should be reflected in the capacity calculations.

The study should address any of the above issues, if applicable, and indicate how they are considered in the final recommendation.

3.1.6 Recommend Alternatives

Through the above analysis steps, a recommended alternative should be identified. The selection of the preferred alternative should be documented in the ICE report. Any conclusions specific to the selected alternative should be documented.

3.2 Phase II – Alternative Selection

For Phase II, Alternative Selection, a more rigorous capacity analysis should be completed. An analysis using acceptable software is required. Currently, RODEL is required for roundabout analysis, SYNCHRO, SIM-TRAFFIC is required for traffic signals and four way stops, and VISSIM may be required for multiple roundabouts, which are a portion of an overall system of traffic control. Due to the high rate of change in modeling software and technology, these requirements could change, please consult with District Traffic Engineering to insure that certain software is required.

The product of this analysis is a comparison of level of service, delay and queue lengths for each alternative. This analysis should provide sufficient detail such that comparisons between alternatives can be made.

The results of the capacity analysis should be summarized in the report. Levels of Service, delay and maximum queue lengths should be reported for all approaches and/or traffic movements for all time periods and analysis years. It is recommended that an electronic copy of the initial conceptual design sketch and analysis be provided as documentation. ICE reports submitted without proper use of software will be rejected.

3.2.1 Prepare Conceptual Designs

Each alternative that is recommended to proceed to Phase II, Alternative Selection, will have concept drawings prepared for the purposes of determining right of way impacts as well as construction costs. The level of detail in the design will be determined by the project manager depending on the location, type of intersection alternative, and other issues. The goal of this step is to have reasonable assurance that all right of way impacts are determined and an accurate cost estimate is obtained.

3.2.2 Identify Right-of-Way Requirements

For the given alternative, determine the Right-of-Way (ROW) needs for the selected alternative(s).

3.2.3 Develop Cost Estimates

Determine the cost estimates for the selected alternative(s).

3.2.4 Political/Public Considerations

Each feasible alternative should be assessed for political viability. In Phase II, typically the local jurisdictions and other important stakeholders would be consulted to determine the acceptability of an alternative. If the result was negative, this alternative should be dropped from further consideration, especially if cost participation is required. During Phase II, the degree of public involvement in the discussion of alternatives must be determined by the project manager in consultation with local stakeholders and Mn/DOT functional units. In any event, stakeholders should be aware of the technical merits of each alternative.

3.2.5 Reevaluate Alternatives

As necessary, perform additional warrant, crash and capacity analysis. Use this information, along with engineering judgment to compare and contrast the alternatives.

3.2.6 Approve Staff Layout

If Phase II is required and alternatives are re-evaluated, the design layout should be approved by DTE staff. This is prior to or concurrent with the reporting process. In general, it is best to receive approval prior to finalizing the report.

3.3 Approval & Report

During this stage, the formal report is created and final approvals are given.

3.3.1 Write Report

The purpose of the ICE report is to document all of the analysis (technical, financial, political) used to determine the recommended alternative.

Depending on the amount of analysis, an actual report may be unnecessary. For some projects, a memorandum may be all that is necessary (e.g., Traffic signal rebuild projects). In that case, a memorandum signed by the District Traffic Engineer with rationale that supports the decision is sufficient. Otherwise, the ICE report should follow the outline below and thoroughly document the process described previously.

Concurrence (Approval) Letter (not needed if report is done internally)

The cover letter must be addressed to the District Traffic Engineer. It should include the name and address of the submitter along with any specific information on expected project letting dates, funding sources and linkages to other projects. The submitter should allow at least one month to obtain approval.

Cover Sheet

The cover sheet requests the approval of the District Traffic Engineer for the recommendations contained in the report. A signature block must be included with spaces for the report preparer (must be a registered engineer in the State of Minnesota), the engineering representative for the agency(s) with jurisdiction over the intersecting roadway and the District Traffic Engineer.

Description of Location

The report must document the location of the project in relation to other roadways and include an accompanying map at a suitable scale.

Existing Conditions

The report must document the existing conditions of the roadway including existing traffic control, traffic volumes, crash data, roadway geometrics, conditions of the roadway, right of way limits, land use, etc. A graphic/layout should be used to display much of this information.

Future Conditions

The report must document future conditions (normally 20 years) based on anticipated development including traffic volumes, new or improved adjacent or parallel roadways, anticipated change in access (additions or removals), etc.

Analysis of Alternatives

The report must include a discussion of each alternative and why it is recommended or not. The report should document the following analyses for each alternative considered: warrant analyses, crash analyses capacity analyses, right of way and construction cost impacts, political considerations, system consistency, and other considerations. Warrant analyses are usually done for existing conditions, however, in some cases future volumes (usually no more than 5 years) can be used if the submitter can document that development is imminent. Crash analysis is done comparing the existing crashes with those anticipated after the change in traffic control. It may be necessary to analyze crashes at nearby intersections if access is proposed to be restricted at the subject intersection. A capacity analysis for each alternative must be completed for existing conditions with and without the improvement. Additionally, a capacity analysis must be done for future conditions (usually 20 years into the future, unless the improvement is anticipated to be temporary (in that case 5 years would be acceptable)). A discussion of the relative intersection delays for each alternative must be included. The Mn/DOT District Traffic Engineering unit should be contacted for acceptable software packages for capacity analysis for each alternative. Currently, RODEL is recommended for isolated roundabouts, VISSIM is recommended for roundabouts in very close proximity to other roundabouts or signalized intersections in addition to RODEL analyses, and SYNCHRO is recommended for traffic signals and all-way stops.

Recommended Alternative

The report must recommend an alternative based upon the alternative analysis and a discussion of the justification factors. The report must document the justification factors, which are appropriate for each alternative and come to a logical conclusion on which alternative is recommended.

Appendices

The report should include supporting data, diagrams and software reports that support the recommendations being made.

3.3.2 DTE Approval

An ICE must be written under the supervision of a licensed Professional Engineer in the State of Minnesota and approved by the District Traffic Engineer. Each district can require additional review and approvals, if it is desired.

1.2.2 Warrants

The information following this sheet is a handout taken from the Minnesota Manual on Uniform Traffic Control Devices (MN MUTCD) sections 4C-1 to 4C-10.

The most current version of the MN MUTCD can be found at:

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

It is recommended that you review all original reference material for updates.

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.

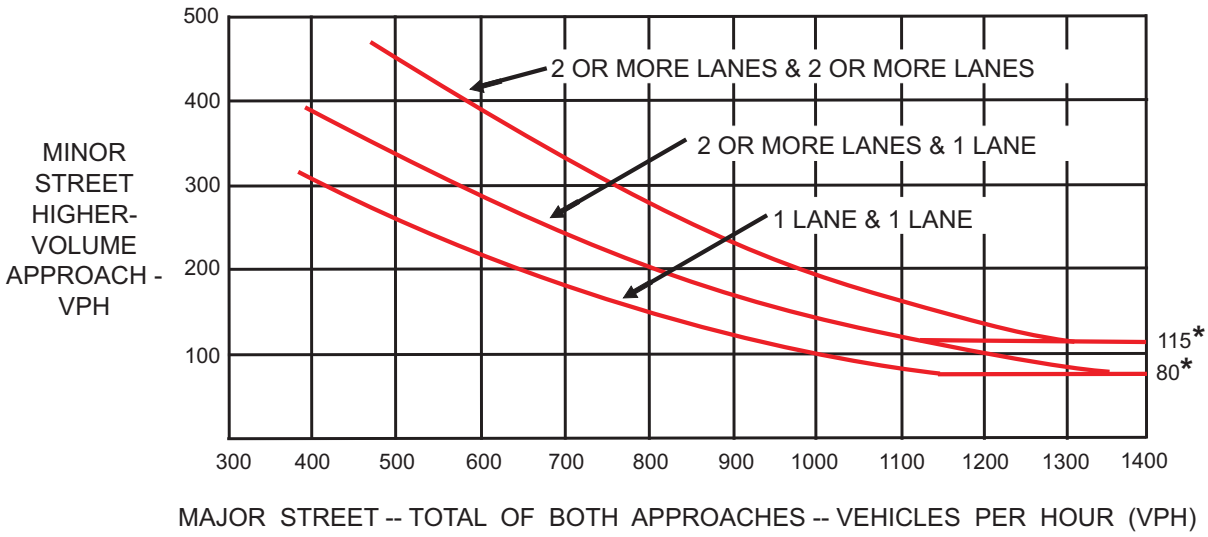
GUIDANCE:

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:

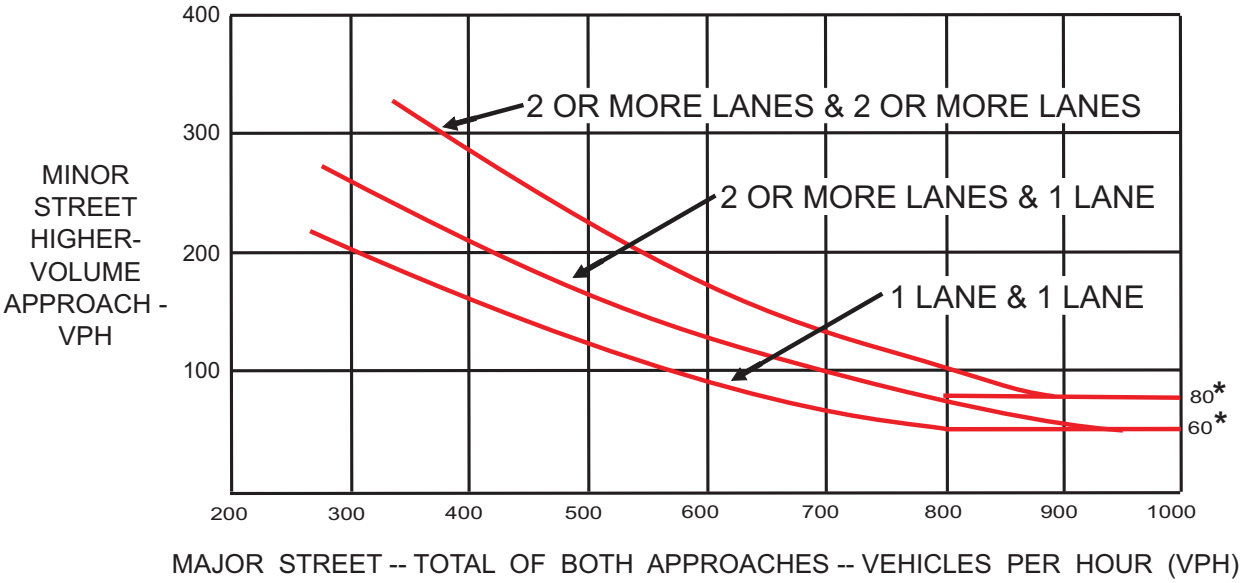
A. The vehicles per hour given in both of the 80 percent columns of Condition A in Table 4C-1 exist on the major-street and the higher-volume minor-street approaches, respectively, to the intersection; and



*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.

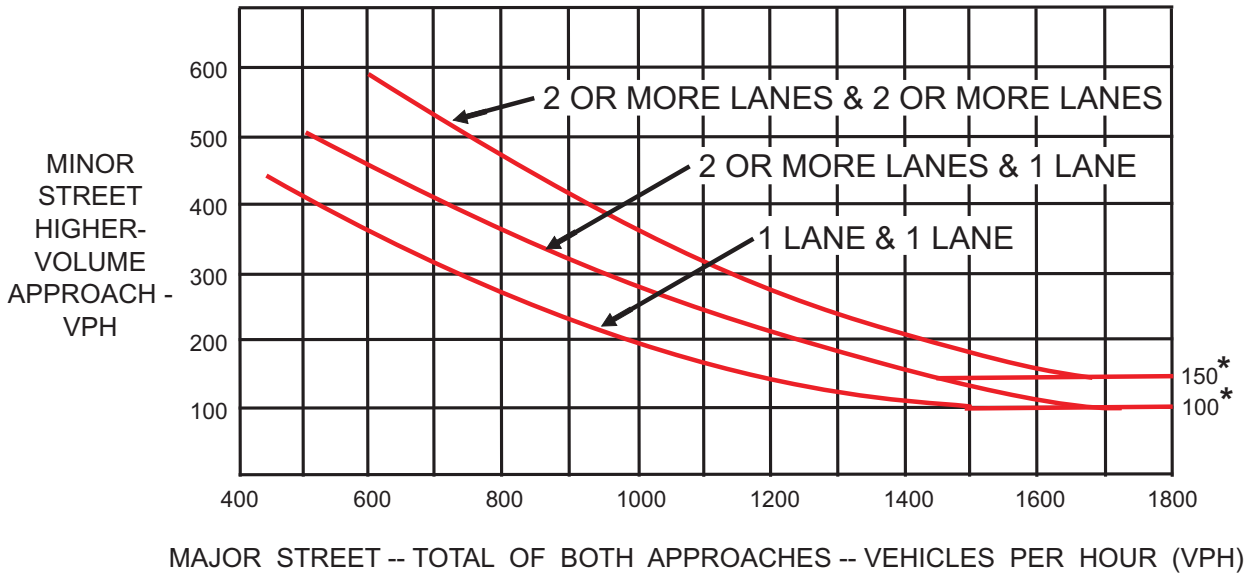
OPTION:

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:

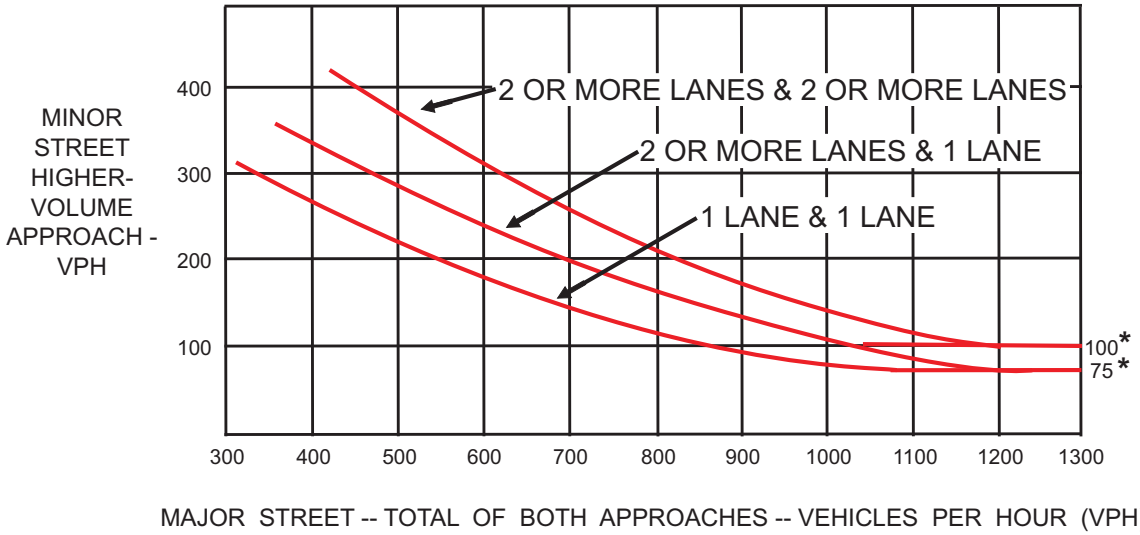
If this warrant is the only warrant met and a traffic control signal is justified by an engineering study, the traffic control signal should be traffic-actuated.



*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.

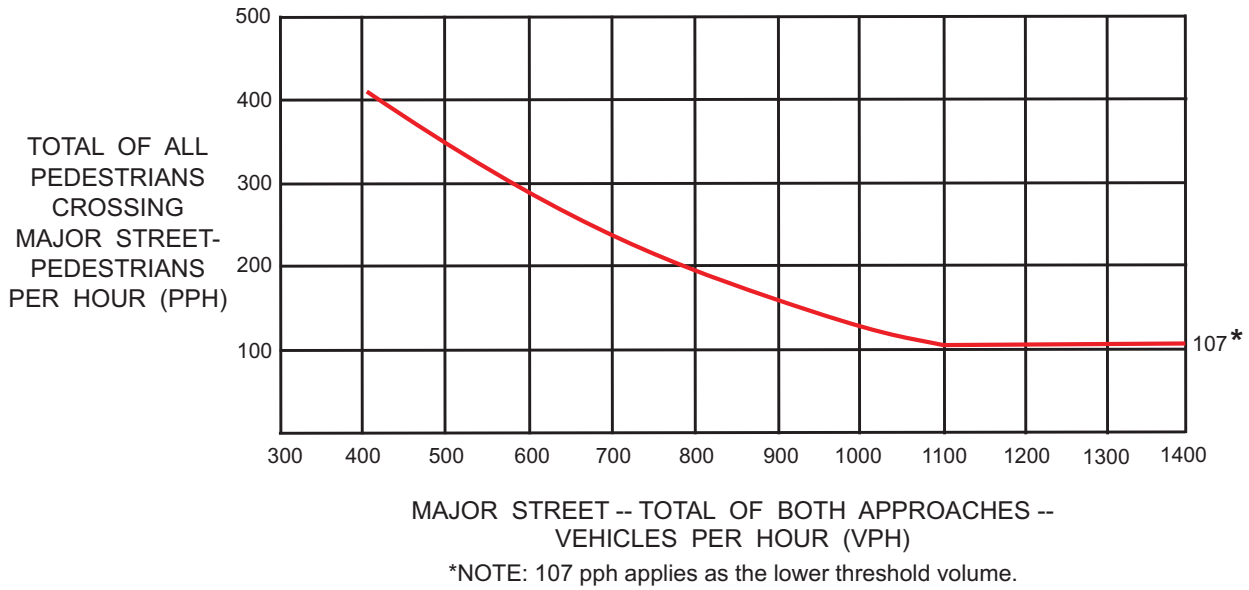
4C.6 Warrant 5, School Crossing

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.

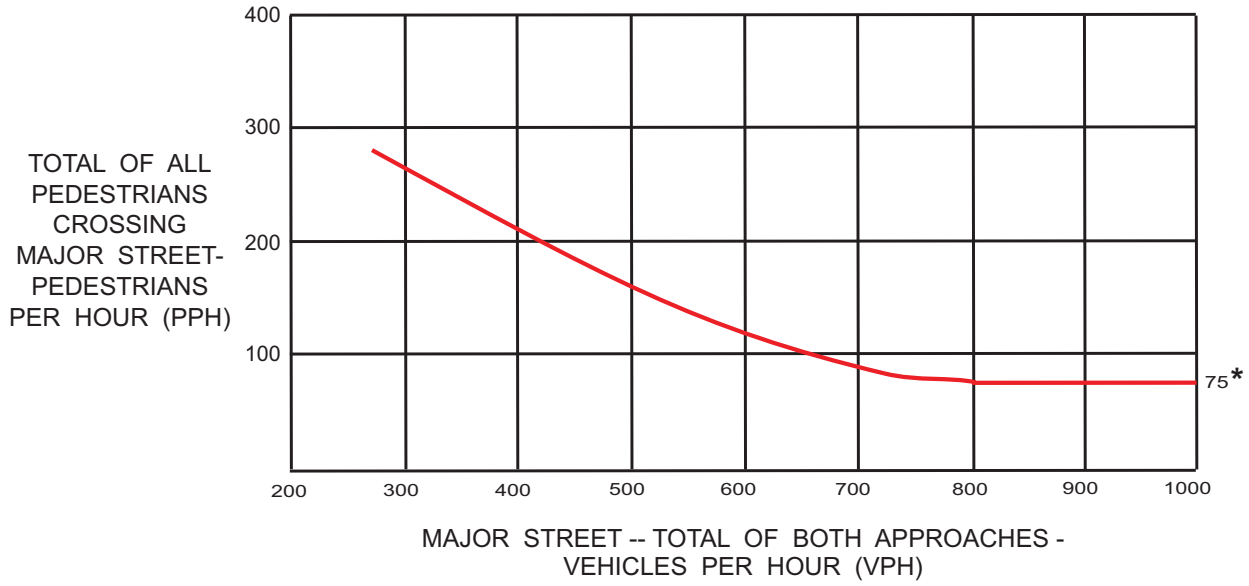
STANDARD:

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.



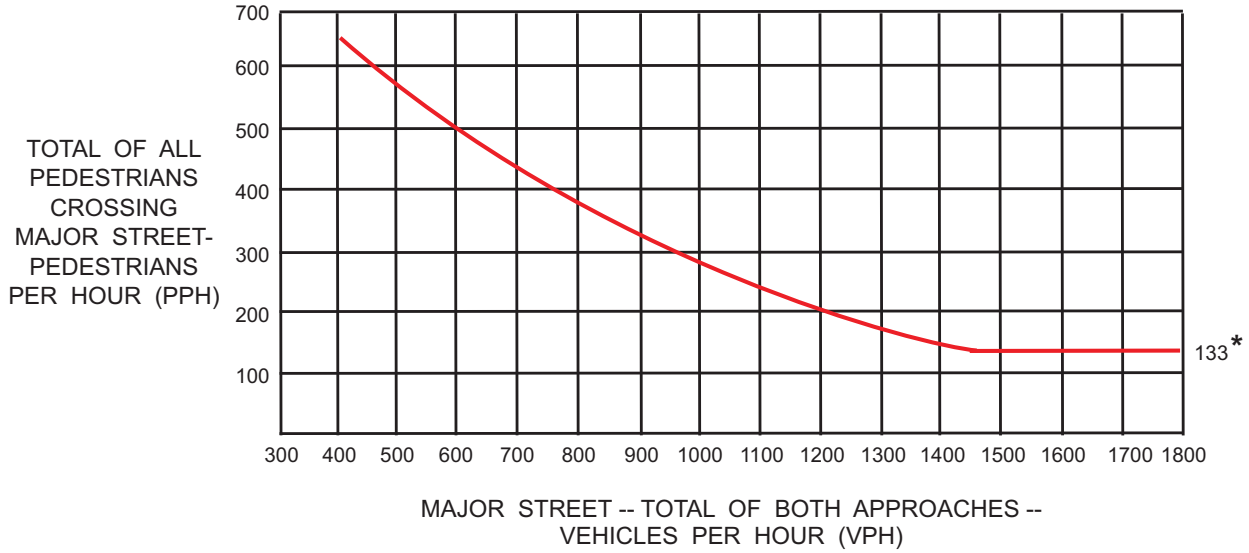
*NOTE: 107 pph applies as the lower threshold volume.

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



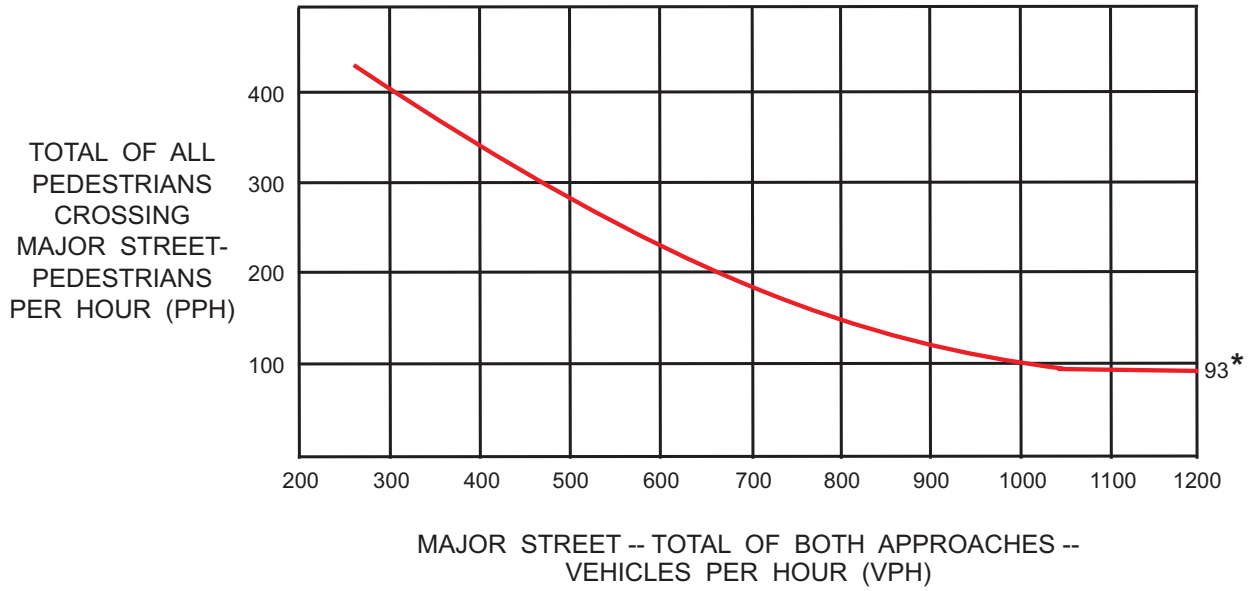
*NOTE: 75 pph applies as the lower threshold volume.

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:

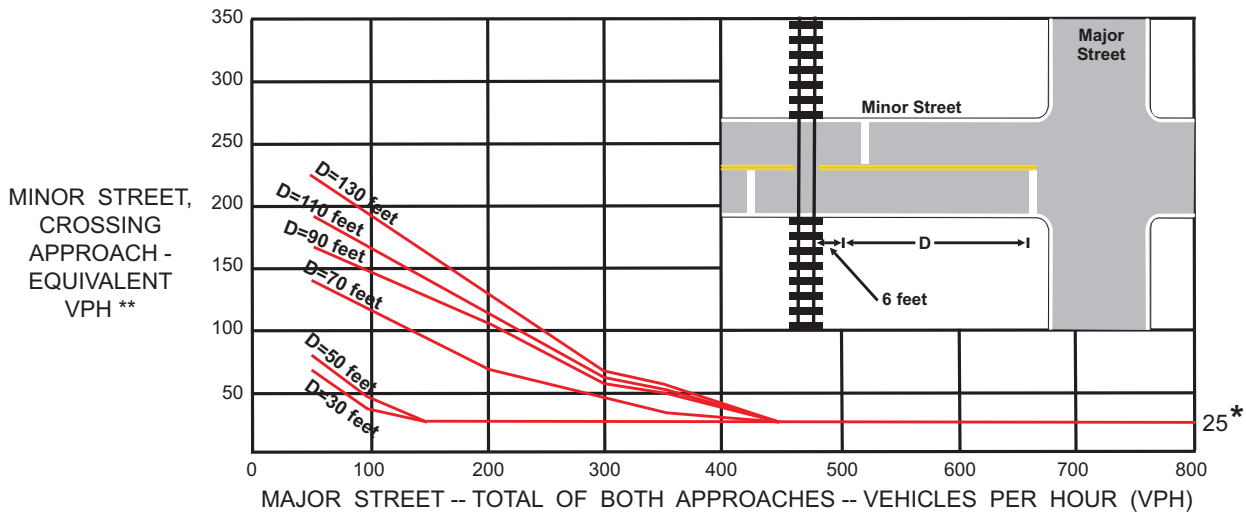
The following considerations apply when plotting the traffic volume data on Figure 4C-9 or 4C-10:

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:

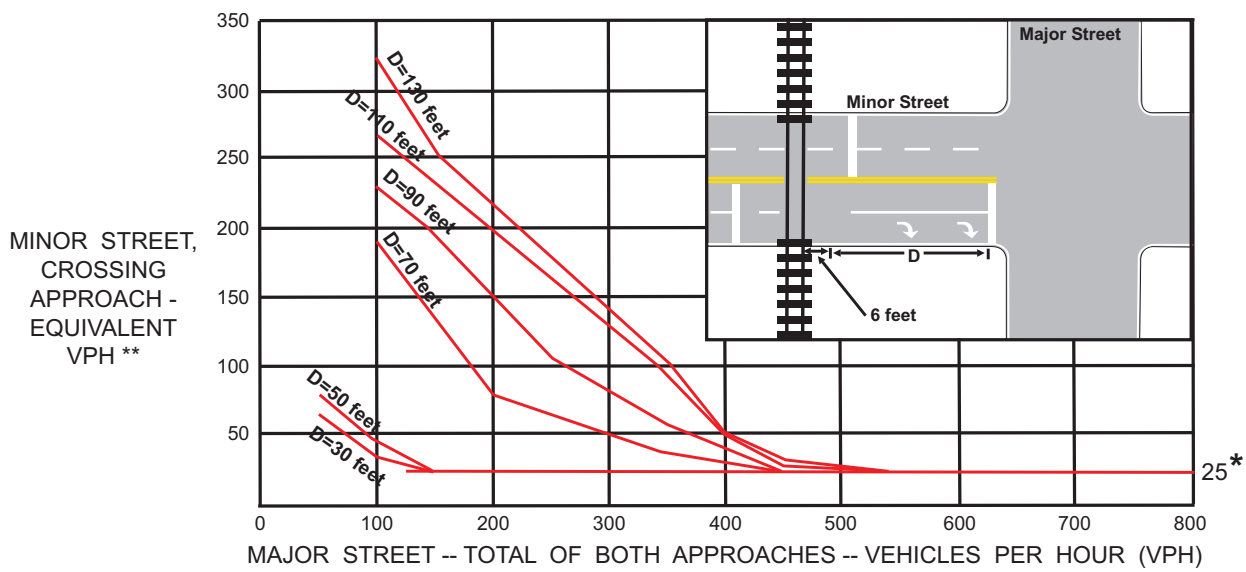
The minor-street approach volume may be multiplied by up to three adjustment factors as provided in Paragraphs 6 through 8.

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

1.3 PRELIMINARY DESIGN

A preliminary signal design checklist and source of power checklist is included in Chapter 5. The following is a sample source of power confirmation letter:

Minnesota Department of Transportation

Metropolitan Division
Waters Edge
1500 West County Road B2

Telephone No. 651.555.5555
Facsimile No. 651.555.5555
E-mail: minnie.dot@dot.state.mn.us

April 22, 2008

Mr. Bud E. Lee
Design Engineer
Minnesota Valley Electric Cooperative (MVEC)
125 Minnesota Valley Electric Drive
Jordan, MN 55352

Dear Mr. Lee:

Subject: SP 1000-00 (T.H. 100 @ CSAH 1)
Source of Power Confirmation for a New Traffic Control Signal Installation
In the City of Anytown, Any County

I am sending this letter as confirmation of our on-site discussion on 4/18/2008. Our proposed project will construct a new traffic control signal system on T.H. 100 @ CSAH 1. The project currently has an October 22, 2008 bid opening date. The Resident Construction Engineer is Jim Volt, Mn/DOT Construction (Phone: 555-555-5555).

The Signal requires a power drop to the new signal service cabinet, as identified within the enclosed draft signal plans, with 100amp, 120/240-volt three-wire service. **Please provide a cost estimate for the hookup charges**.

At this time, it is anticipate that:

1) The City of Anytown will be the billable part for all connection and monthly power costs associated with the signals and luminaires.
2) We didn't decide on the meter address when we met in the field, however, I propose the following: 99999 Highway 100. **Please verify this proposed meter address**.
3) The in-place power poles at the intersection will need to be relocated and/or placed underground. Our roadway design staff will be contacting you regarding the design.
4) No power application form is necessary for the project.

If you have any questions or need additional information, please call me.

Sincerely,
Minnesota Department of Transportation

Minnie Dot
Metro District Signal Design Project Manager

1.3.1 Utilities

To locate utilities during pre-design activities, a Gopher State One Call request can be made.

Phone the Gopher State One Call personnel named below and indicate that you are requesting a “15 day Design Request”. Gopher State will then process your request as you stay on the line with them.

Before calling Gopher State One Call, you should have the Trunk Highway number, County name, City or Township name (especially in rural areas), section-township-range of the area being requested, note any cross streets or roads in the area, and distance from centerline needed on one or both sides of the highway. In the Metro area, you may reference the page number and grid location from the Hudson’s Street Atlas.

Note: Every possible interaction should occur between the designer and the water resources engineer to eliminate potential conflicts between water resources structures and signal equipment. Be sure to stake as early as possible if new utilities are going to be added.

To leave a message with the Metro Division, contact the receptionist at 651-234-7500. Should you have problems, please contact the Director of Education & Public Relations.

1.4 AGREEMENTS

1.4.1 Project Manager Considerations

Agreement terms (cost participation, power supply, design responsibilities, operation responsibilities and major/minor maintenance responsibilities including post installation locate) 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.

Benefits of effective project management, including a kick off meeting [see checklist in Chapter 5] and cooperative signal agreement terms discussion, include:

- Railroad crossing or right of way issues which may affect the project scope and/or time line can be identified.
- The importance of power company design contacts can be emphasized.
- Design issues are discussed and the overall scope of the project is reviewed to ensure that all safety, operation, and maintenance issues are addressed.
- State furnished materials and labor can be accurately defined and estimated. This produces a more accurate overall project cost used in the agreement as opposed to the contract cost estimate used for the letting. [see state furnished materials and labor graphic]
- Pay item organization/choice, specific to the project, can be discussed.

Refer to page 1-1 and the corresponding sections from the TEM for additional information. Also, refer to the Cooperative Purchasing Venture at the following web site:

http://www.mmd.admin.state.mn.us/cpv2.htm

"The Cooperative Purchasing Venture (CPV) is a members-only program that enables participants to purchase goods and services under contract terms established by the state of Minnesota. The CPV can: reduce or eliminate product specification research time, enhance and simplify product selection, minimize time identifying new vendors, and reduce or eliminate the time and costs to award, process and maintain a contract."

1.4.2 Preliminary Signal Design Concurrence Process

Signal designers should meet and confer to agree on preliminary signal design. The design topics to be discussed include the following:

- general nature of the signal project: new installation, minor or major revisions
- phasing of the intersection, relation of proposed phasing to the traffic volumes and turning movements; use of protected-permissive left turn phasing rather than protected-only; use of overlaps
- use of 4- and 5-section heads and non-standard bracketing
- appropriateness of poles or pedestals for the site
- placement of signal standards to ensure legal placement of all vehicle and pedestrian signal indications. See Chapter 3 for signal head placement diagrams.
- placement of pedestrians pushbuttons relative to signal standards and in place sidewalks and crosswalks
- detector placement and functions. See Chapter 4 for loop detector placement diagrams.
- placement and type of handholes
- design of equipment pad
- type of service equipment
- use of battery backup systems
- for revised systems, the wording of the notes on signal structure revision

1.4.3 Signal Agreements

Cooperative agreements, which specify the sharing of cost, maintenance, and operation of signals, are prepared by MnDOT. Upon completion by the district/division of its work, and on receipt of the plans and agreement request by the District/Division Traffic Engineer, the agreement will be prepared in basically the following manner:

- A pre-agreement letter shall be sent by the District or Division Traffic Office to all the municipalities that may be involved in the cost sharing of the construction and maintenance of the traffic signal. The pre-agreement letter shall contain an estimate of the costs of construction and maintenance costs. The cost will be shared by each agency depending on the number of legs at the intersection. Private entrances will be considered a municipal leg.
- The municipalities shall provide a resolution stating their willingness to participate in the cost of the project, or to perform certain duties as part of the project.
- MnDOT will prepare the special provisions cost estimate from the finished plan provided by the district or division.
- The request for agreement will be approved by the Plans and Coordination Engineer and by the Electrical Devices Engineer and will be submitted to the Signal Unit
- Planning and Programming will be contacted to determine the status of approval for federal aid funds by the FHWA.
- The Technical Support Unit will prepare the agreement.
- The copies will then be sent to the District/Division Traffic Engineer.
- The District/Division Traffic Engineer will review the agreement and, if they approve it, will submit all copies to the municipality or county for approval, signatures, and seals. This done, the copies will be returned to the District/Division Traffic Engineer.

- The District/Division Traffic Engineer will check the agreement to ensure proper execution and inclusion of the resolution, submit to the Transportation District/Division Engineer for signature and return to the Signal Unit. Agreements should be back to the District/Division Traffic Engineer more than two weeks before the proposed letting date, and if returned later may require special handling. The District/Division Traffic Engineer should follow up all agreements being processed to ensure timely returns.
- The Signal Unit shall review the agreement for signatures and seals, and for submittal to the Assistant Commissioner for signature.
- The agreement will then be further processed through the Assistant Attorney General, Department of Administration, Budget and the Department of Finance as needed.
- Copies and originals of the fully executed agreement will be properly distributed by the Signal Unit.

Agreements for signal construction in which the municipality or county do not share cost (but share the operation and maintenance) will be identified by an "M" following the agreement number. This is a maintenance cooperative agreement and will be prepared and processed substantially as described above.

1.4.4 State Aid and Other Agencies

Traffic signal plans handled by MnDOT 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 registered engineer.

1.4.5 Cost Sharing

The Cost Participation Policy and Procedures can be found at the following link:

http://www.dot.state.mn.us/policy/financial/fm011.html

Cost participation is determined as shown in the example on the following page.

COST PARTICIPATION

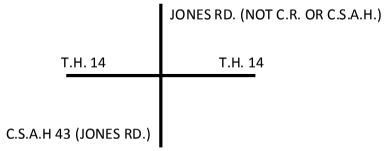
NOTE:

- THE DESIGNER SHOULD ALWAYS CONFER WITH THE PROJECT MANAGER TO ENSURE ACCURATE COST PARTICIPATION BREAKDOWNS AND PRESENTATION.
- STATE AID PARTICIPATION MUST BE IDENTIFIED IN COST PARTICIPATION BREAKDOWNS. THE DESIGNER MUST WORK WITH THE PROJECT MANAGER AND LOCAL AGENCY TO ENSURE STATE AID INFORMATION IS COMPLETE AND ACCURATE.
- TEMPORARY SIGNAL SYSTEMS, REQUIRED FOR PROJECT STAGING, ARE THE COST RESPONSIBILITY OF THE AGENCY WHO PROGRAMS AND MANAGES THE PROJECT. (FEDERAL COST PARTICIPATION MAY APPLY.)
- IF FEDERAL FUNDING IS USED ON A PROJECT, AND THERE IS A NEED TO HAUL SALVAGED ITEMS, A SEPARATE PAY ITEM IS NEEDED TO COVER HAULING COSTS. THE HAUL COSTS ARE PAID BY THE AGENCY WHO PROGRAMMED AND MANAGED THE PROJECT. FEDERAL FUNDS CANNOT BE APPLIED TO HAUL SALVAGE ITEMS.

ASSUMPTIONS FOR THIS EXAMPLE:

- FEDERAL FUNDS ARE ONLY APPLIED TO THE STATE FUNDS, UNLESS THE LOCAL SHARE IS IDENTIFIED IN THE STIP AS LOCAL FEDERAL.
- THE COUNTY INVOLVED HAS A POLICY TO APPLY 50% OF NEW SIGNAL OR INTERCONNECT COSTS TO THE LOCAL MUNICIPALITY
- THE COUNTY INVOLVED DOES NOT PARTICIPATE IN EMERGENCY VEHICLE PREEMPTION INSTALLATION.
- THE STATE AND LOCAL AGENCIES SUPPORT THIS PROJECT AND HAVE FUNDING SOURCES AVAILABLE.
- ALL INTERSECTIONS ARE IN THE SAME CITY AND COUNTY.

SIGNAL SYSTEM COST PARTICIPATION EXAMPLES



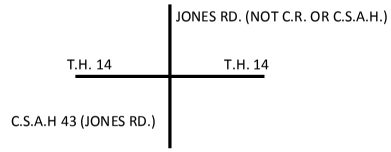
① 4 LEGS TOTAL AT THE INTERSECTION
- 2 LEGS T.H. (STATE)
- 1 LEG C.S.A.H. (COUNTY)
- 1 LEG CITY ST. (CITY)

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

EMERGENCY VEHICLE PREEMPTION (EVP) COST PARTICIPATION EXAMPLE



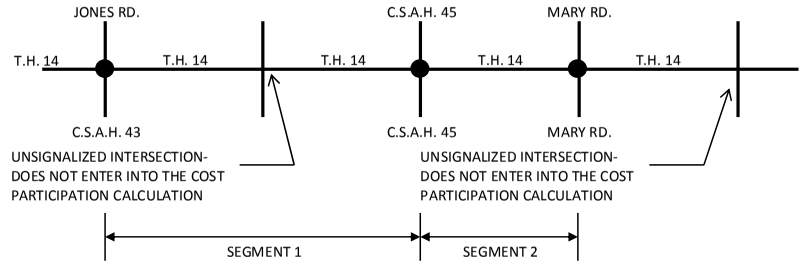
① 4 LEGS TOTAL AT THE INTERSECTION
- 2 LEGS T.H. (STATE)
- 1 LEG C.S.A.H. (COUNTY)
- 1 LEG CITY ST. (CITY)

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
- 50% CITY

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

INTERCONNECT COST PARTICIPATION EXAMPLE:



- WHILE SIGNAL SYSTEM COST PARTICIPATION INVOLVES LEGS OF THE INTERSECTION, INTERCONNECT COST PARTICIPATION INVOLVES LEGS OF SEGMENTS.
- DISTANCE BETWEEN SIGNALIZED INTERSECTIONS IS NOT A FACTOR IN PARTICIPATION CALCULATION
- ATTRIBUTE OWNERSHIP OF LEGS OF EACH SEGMENT, THEN COMBINE AND DETERMINE OWNERSHIP PROPORTION.

① SEGMENT 1 HAS 4 LEGS TOTAL
- 2 LEGS T.H. (STATE)
- 1.5 LEGS C.S.A.H. (COUNTY)
- 0.5 LEG CITY ST. (CITY)

② SEGMENT 2 HAS 4 LEGS TOTAL
- 2 LEGS T.H. (STATE)
- 1 LEGS C.S.A.H. (COUNTY)
- 1 LEG CITY ST. (CITY)

③ COMBINED PROPORTION OF TOTAL OF 8 LEGS IN BOTH SEGMENTS:
- 50% STATE
- 31% COUNTY
- 19% CITY

④ APPLY THE COUNTY POLICY AND THE FEDERAL PARTICIPATION-THE FINAL PROPORTIONS ARE:
- 40% FEDERAL
- 10% STATE
- 31% COUNTY
- 19% CITY

⑤ WHEN APPLIED TO THE QUANTITIES CHART, THE PERCENTAGES BECOME:
- 0.4 FEDERAL
- 0.1 STATE
- 0.31 COUNTY
- 0.19 CITY

1.5 BATTERY BACKUP POWERED TRAFFIC SIGNALS

MnDOT has developed a service cabinet that can accommodate a battery backup setup. Some of the key items/features include:

- The SSB service cabinet is designed to accommodate a uninterrupted power supply (UPS) and the batteries. It will be each agencies choice to use a UPS and batteries or not.
- New SSB service cabinet with batteries will not fit old bolt pattern.
- Municipal agreement typically determines who will pay for and maintains batteries.
- Installation includes a UPS and 4 batteries at approximately $2500 total each; approximate 5 year warranty; batteries do not need to be cycled; can buy a monitor to test batteries; replace every 6-7 years.
- Batteries can run signal in full operation for approximately 2 hours and then or operate the signal run in flash mode for approximately 4 additional hours.
- The SSB cabinet pad details an additional communication conduit that is critical within the cabinet.
- All signals interconnected with railroad should have a battery backup system installed.
- When at a rail crossing with interconnect, battery backup will be split as normal signal costs, percentage of ownership of approaches.
- On retrofit projects sharing the anchor rods and replacing some may be required.

In the state of Minnesota, a black (out of power) traffic control signal is treated as an uncontrolled intersection.

1.6 PEDESTRIAN HYBRID BEACONS

From the Minnesota Manual on Uniform Traffic Control Devices (Section 4F.1), "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 High-intensity Activated cross-WalK.

The HAWK signal should confirm to all APS guidelines. It must also follow the guidelines detailed in Chapter 4F of the MN MUTCD (included as a handout on page 1-77). Note that this section of the MN MUTCD includes guidelines for the installation, design of the beacon, and operation of the beacon.

Exhibit 1-2 HAWK Signal

1.6.1 Justification and Cost Participation

Signal Warrant – MnDOT will participate if the HAWK meets ped warrants (Signal Warrant 5; Pedestrian Volume and Warrant 6; School Crossing) for a traffic signal. Participation will be 50/50.

HAWK Guidelines – If meeting the less restrictive guidelines for a hawk signal, MnDOT will allow the hawk to be installed on a Trunk highway. State cost participation will be 50/50 but will depend on available funding.

No warrant or guidelines – HAWK System will not be allowed on Trunk Highways.

1.6.2 Agreements

Agreement will be made for each HAWK system. Agreements will be similar to current signal agreements; Locals pay power, paint, ped crossing and stop lines, street lights. MnDOT will operate and bill back 100% for any work required.

1.6.3 Other Conclusions

- If developer driven, developer will pay all cost's for the HAWK.
- No Intersection Control Evaluation needed.
- HAWK must be ADA compliant.
- EVP will not be allowed to preempt the walk or walk clearance times. EVP can only be used to delay the ped call. If a preempt call came in before a pedestrian pushed the button or the ped pushed the button during a

preempt call, the call would be delayed until the EVP call has terminated. EVP has limited value at a HAWK system.

- A Hawk system (Pedestrian Hybrid Beacon) and a traffic signal are not the same. Federal MUTCD defines each differently.

From the driver's standpoint, the signal operation is as follows:

1 

The HAWK remains **DARK** for traffic unless a pedestrian activates the push-button.

2 

When a pedestrian presses the button, approaching drivers will see a **FLASHING YELLOW** signal for a few seconds, indicating that the signal has been activated.

3 

The flashing yellow is followed by a **SOLID YELLOW** signal**,** indicating that motorists should reduce speed and be prepared to stop.

4 

The solid yellow is followed by double **SOLID RED** signals, requiring drivers to stop.

5 

Flashing

The double solid red signals are followed by wig wag **FLASHING RED** signals. The signal will then go dark until activated again by a pedestrian.

During the wig wag **FLASHING RED** signal indication, drivers are required to come to a full **STOP,** but may proceed when pedestrians have cleared the crosswalk and it is safe to proceed.

Additional information on the HAWK signal can be found by visiting,

www.dot.state.mn.us/d3/newsrels/09/10/15hawkcrosswalk.html.

The information following this page is a handout taken from the MN MUTCD, Chapter 4F Pedestrian Hybrid Beacons.

These guidelines can be found at:

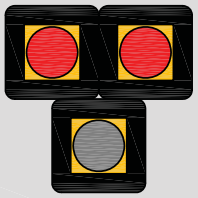
www.dot.state.mn.us/trafficeng/publ/index.html

It is recommended that you review all original reference material.

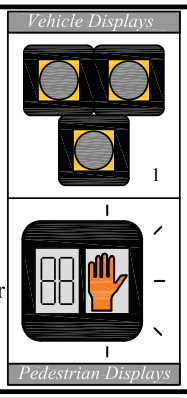
HAWK Pedestrian Crossing System

City of St. Cloud
Traffic Systems Services
St. Cloud, Minnesota

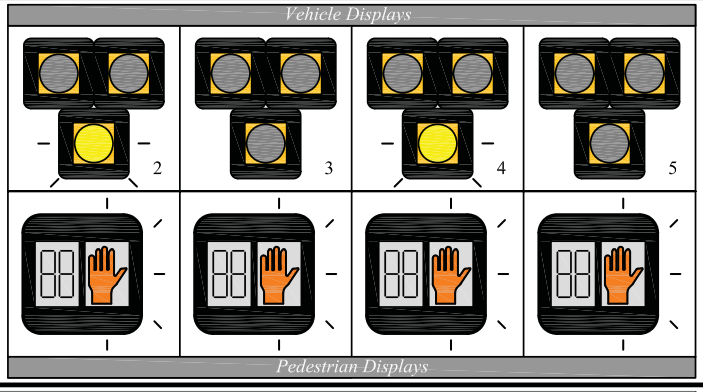
The HAWK Pedestrian Traffic Signal Display provides a unique traffic signal display for the motorist. The unique shape and operation of the HAWK signal provides improved safety for the pedestrian crossing a roadway, reduced delay to the motorist and a traffic signal system with minimal energy consumption. When the system is in rest, the vehicle signal displays are dark while the Don't Walk Raised Hand symbol on the pedestrian displays are the only indications displayed. The unique shape and operation of the signal displays quickly identify the signal as a pedestrian crossing with the flashing yellow display, the dual red display and the alternating red display.



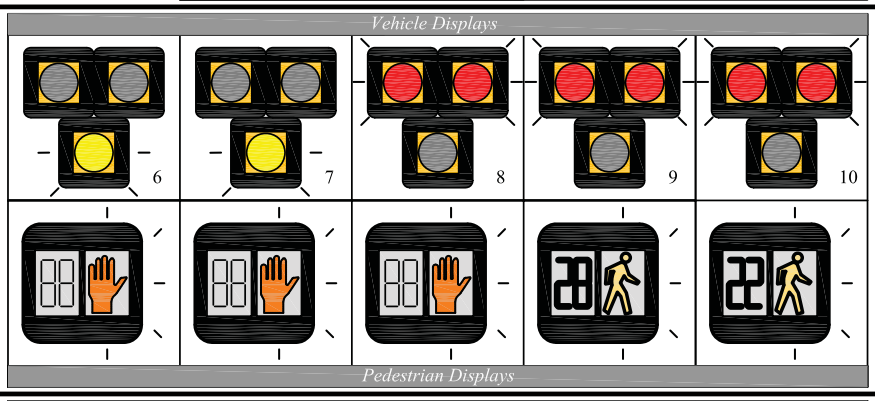
The vehicle indication remains dark when the pedestrian crossing is not in use. The raised Don't Walk hand symbol remains on during this timing interval. (Note: The number in the lower right corner of the signal display indicates the order in which the signal sequence will occur.)



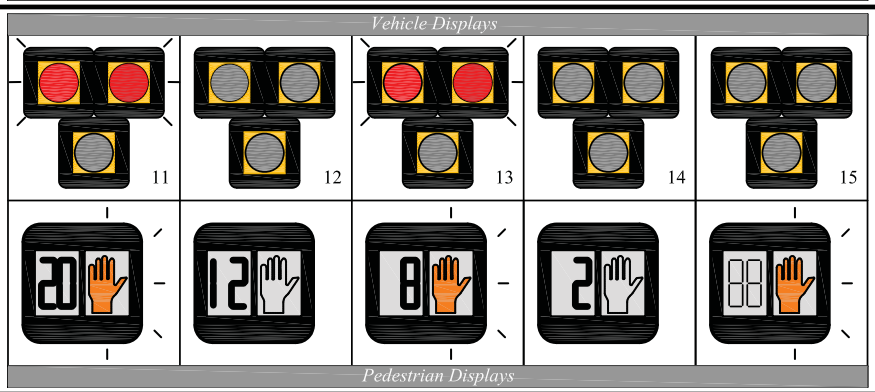
After the pedestrian button has been depressed, the yellow indication in the traffic signal head flashes yellow to indicate to the motorist that the display will soon be transitioning to a red display. The raised hand on the pedestrian display remains on during this time period.



Upon completion of the flashing yellow interval, the yellow display goes to a solid yellow for a period of time. After this timing period the dual red indication is displayed. After another clearance period, the Walking Person indication along with the countdown display becomes visible on the pedestrian display. The pedestrian may now start walking across the street. An audible system will also notify the pedestrian that they may now proceed across the street.



After the pedestrians have had time to enter the crosswalk area with the Walk display showing, the pedestrian Walk indication transitions to the flashing Raised Hand display while the countdown display begins. At the same time the flashing Raised Hand display becomes visible, flashing dual red displays become visible to the motorist. With the dual flashing red displays, the motorist may carefully proceed provided the pedestrians have cleared the crossing. At the end of the countdown period, the solid Raised Hand is once again displayed and the traffic signal indications for the motorists go black.



PART 4. HIGHWAY TRAFFIC SIGNALS
Chapter 4F. Pedestrian Hybrid Beacons

4F.1 Applications of Pedestrian Hybrid Beacons

SUPPORT:

A pedestrian hybrid beacon is a special type of hybrid beacon used to warn and control traffic at an unsignalized location to assist pedestrians in crossing a street or highway at a marked crosswalk.

OPTION:

A pedestrian hybrid beacon may be considered for installation to facilitate pedestrian crossings at a location that does not meet traffic signal warrants (see Chapter 4C), or at a location that meets traffic signal warrants under Sections 4C.5 and/or 4C.6 but a decision is made to not install a traffic control signal.

STANDARD:

If used, pedestrian hybrid beacons shall be used in conjunction with signs and pavement markings to warn and control traffic at locations where pedestrians enter or cross a street or highway. A pedestrian hybrid beacon shall only be installed at a marked crosswalk.

GUIDANCE:

If one of the signal warrants of Chapter 4C is met and a traffic control signal is justified by an engineering study, and if a decision is made to install a traffic control signal, it should be installed based upon the provisions of Chapters 4D and 4E.

If a traffic control signal is not justified under the signal warrants of Chapter 4C and if gaps in traffic are not adequate to permit pedestrians to cross, or if pedestrian delay is excessive, the need for a pedestrian hybrid beacon should be considered on the basis of an engineering study that considers major-street volumes, speeds, widths, and gaps in conjunction with pedestrian volumes, walking speeds, and delay.

For a major street where the posted or statutory speed limit or the 85th-percentile speed is 35 mph or less, the need for a pedestrian hybrid beacon should be considered if the engineering study finds that the plotted point representing the vehicles per hour on the major street (total of both approaches) and the corresponding total of all pedestrians crossing the major street for 1 hour (any four consecutive 15-minute periods) of an average day falls above the applicable curve in Figure 4F-1 for the length of the crosswalk.

For a major street where the posted or statutory speed limit or the 85th-percentile speed exceeds 35 mph, the need for a pedestrian hybrid beacon should be considered if the engineering study finds that the plotted point representing the vehicles per hour on the major street (total of both approaches) and the corresponding total of all pedestrians crossing the major street for 1 hour (any four consecutive 15-minute periods) of an average day falls above the applicable curve in Figure 4F-2 for the length of the crosswalk.

For crosswalks that have lengths other than the four that are specifically shown in Figures 4F-1 and 4F-2, the values should be interpolated between the curves.

4F.2 Design of Pedestrian Hybrid Beacons

STANDARD:

Except as otherwise provided in this Section, a pedestrian hybrid beacon shall meet the provisions of Chapters 4D and 4E.

A pedestrian hybrid beacon face shall consist of three signal sections, with a CIRCULAR YELLOW signal indication centered below two horizontally aligned CIRCULAR RED signal indications (see Figure 4F-3).

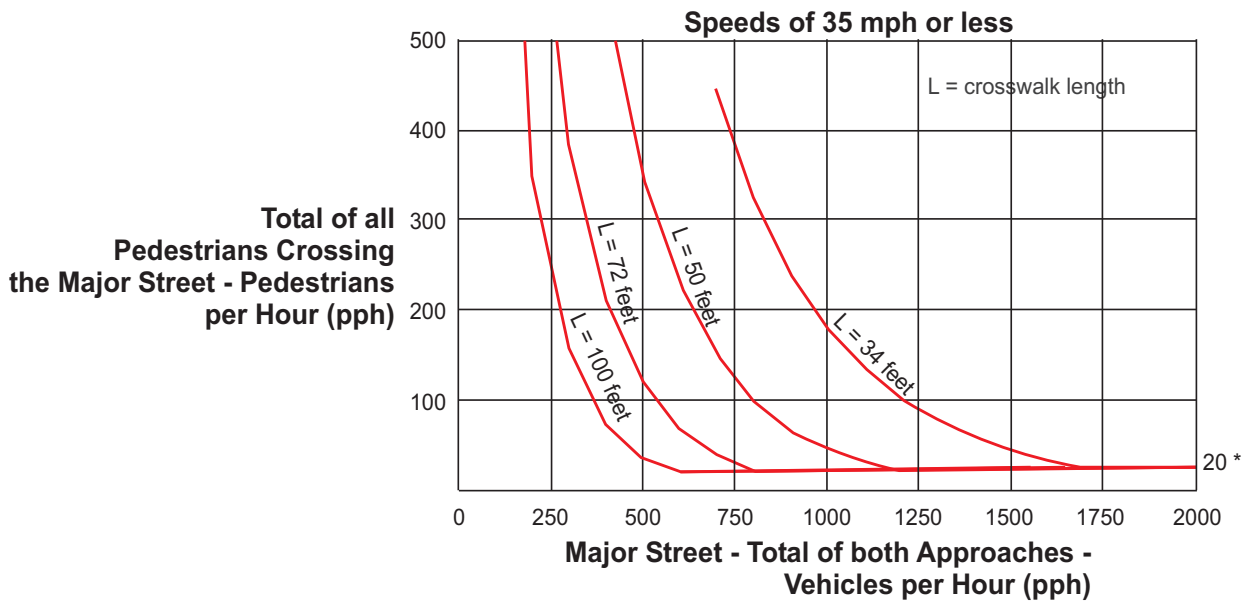
When an engineering study finds that installation of a pedestrian hybrid beacon is justified, then:

A. At least two pedestrian hybrid beacon faces shall be installed for each approach of the major street,
B. A stop line shall be installed for each approach to the crosswalk,
C. A pedestrian signal head conforming to the provisions set forth in Chapter 4E shall be installed at each end of the marked crosswalk, and
D. The pedestrian hybrid beacon shall be pedestrian actuated.

GUIDANCE:

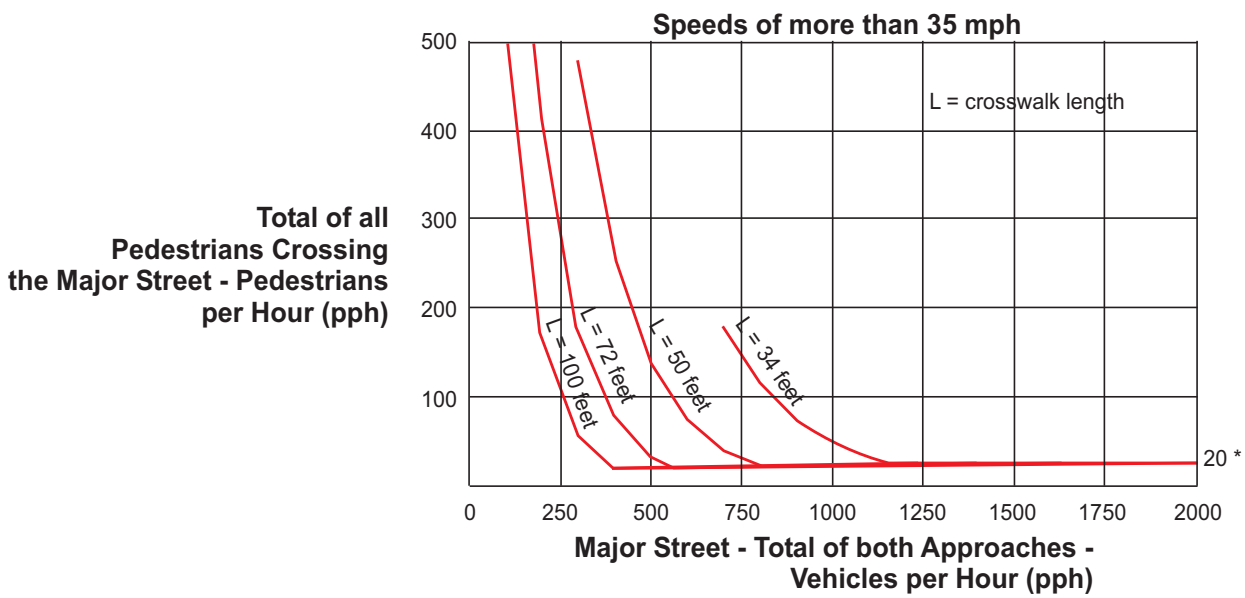
When an engineering study finds that installation of a pedestrian hybrid beacon is justified, then:

A. The pedestrian hybrid beacon should be installed at least 100 feet from side streets or driveways that are controlled by STOP or YIELD signs when not installed at an intersection,
B. Parking and other sight obstructions should be prohibited for at least 100 feet in advance of and at least 20 feet beyond the marked crosswalk, or site accommodations should be made through curb



* Note: 20 pph applies as the lower threshold volume

Figure 4F-1. Guideline for the Installation of Pedestrian Hybrid Beacons on Low-Speed Roadways



* Note: 20 pph applies as the lower threshold volume

Figure 4F-2. Guideline for the Installation of Pedestrian Hybrid Beacons on High-Speed Roadways

extensions or other techniques to provide adequate sight distance,

C. The installation should include suitable standard signs and pavement markings, and

D. If installed within a signal system, the pedestrian hybrid beacon should be coordinated.

E. If installed at an intersection, appropriate side street traffic control should be considered.

On approaches having posted or statutory speed limits or 85th-percentile speeds in excess of 35 mph and on approaches having traffic or operating conditions that would tend to obscure visibility of roadside hybrid beacon face locations, both of the minimum of two pedestrian hybrid beacon faces should be installed over the roadway.

On multi-lane approaches having a posted or statutory speed limits or 85th-percentile speeds of 35 mph or less, either a pedestrian hybrid beacon face should be installed on each side of the approach (if a median of sufficient width exists) or at least one of the pedestrian hybrid beacon faces should be installed over the roadway.

A pedestrian hybrid beacon should comply with the signal face location provisions described in Sections 4D.11 through 4D.16.

STANDARD:

A CROSSWALK STOP ON RED (symbolic circular red) (R10-23) sign (see Section 2B.53) shall be mounted adjacent to a pedestrian hybrid beacon face on each major street approach. If an overhead pedestrian hybrid beacon face is provided, the sign shall be mounted adjacent to the overhead signal face.

OPTION:

A Pedestrian (W11-2) warning sign (see Section 2C.50) with an AHEAD (W16-9P) supplemental plaque may be placed in advance of a pedestrian hybrid beacon. A warning beacon may be installed to supplement the W11-2 sign.

GUIDANCE:

If a warning beacon supplements a W11-2 sign in advance of a pedestrian hybrid beacon, it should be programmed to flash only when the pedestrian hybrid beacon is not in the dark mode.

STANDARD:

If a warning beacon is installed to supplement the W11-2 sign, the design and location of the warning beacon shall comply with the provisions of Sections 4L.1 and 4L.3.

4F.3 Operation of Pedestrian Hybrid Beacons

STANDARD:

Pedestrian hybrid beacon indications shall be dark (not illuminated) during periods between actuations.

Upon actuation by a pedestrian, a pedestrian hybrid beacon face shall display a flashing CIRCULAR yellow signal indication, followed by a steady CIRCULAR yellow signal indication, followed by both steady CIRCULAR RED signal indications during the pedestrian walk interval, followed by alternating flashing CIRCULAR RED signal indications during the pedestrian change interval (see Figure 4F-3). Upon termination of the pedestrian change interval, the pedestrian hybrid beacon faces shall revert to a dark (not illuminated) condition.

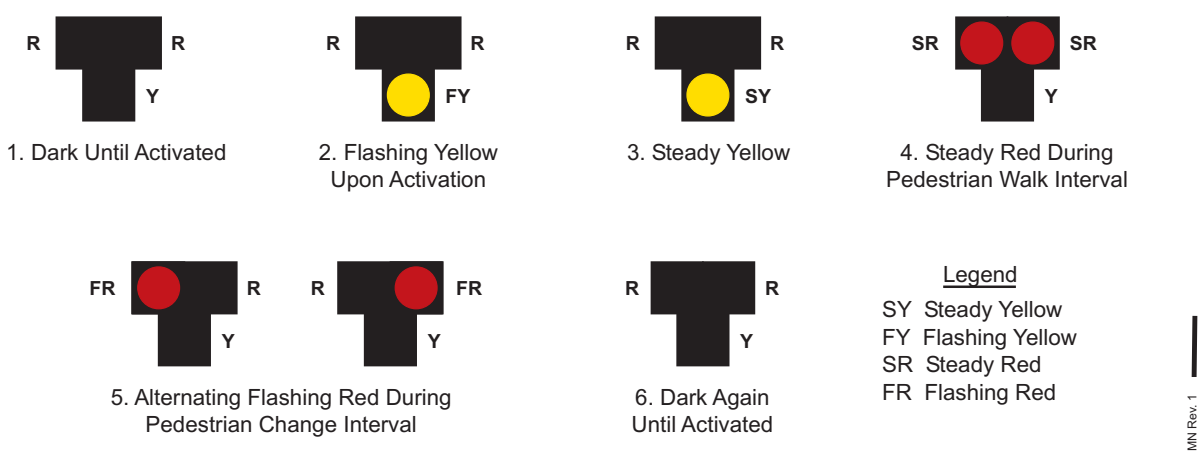


Figure 4F-3. Sequence for a Pedestrian Hybrid Beacon

Except as provided in the following Option, the pedestrian signal heads shall continue to display a steady UPRAISED HAND (symbolizing DONT WALK) signal indication when the pedestrian hybrid beacon faces are either dark or displaying flashing or steady CIRCULAR yellow signal indications. The pedestrian signal heads shall display a WALKING PERSON (symbolizing WALK) signal indication when the pedestrian hybrid beacon faces are displaying steady CIRCULAR RED signal indications. The pedestrian signal heads shall display a flashing UPRAISED HAND (symbolizing DONT WALK) signal indication when the pedestrian hybrid beacon faces are displaying alternating flashing CIRCULAR RED signal indications. Upon termination of the pedestrian change interval, the pedestrian signal heads shall revert to a steady UPRAISED HAND (symbolizing DONT WALK) signal indication.

OPTION:

Where the pedestrian hybrid beacon is installed adjacent to a roundabout to facilitate crossings by pedestrians with visual disabilities and an engineering study determines that pedestrians without visual disabilities can be allowed to cross the roadway without actuating the pedestrian hybrid beacon, the pedestrian signal heads may be dark (not illuminated) when the pedestrian hybrid beacon faces are dark.

GUIDANCE:

The duration of the flashing yellow interval should be determined by engineering judgment.

STANDARD:

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

GUIDANCE:

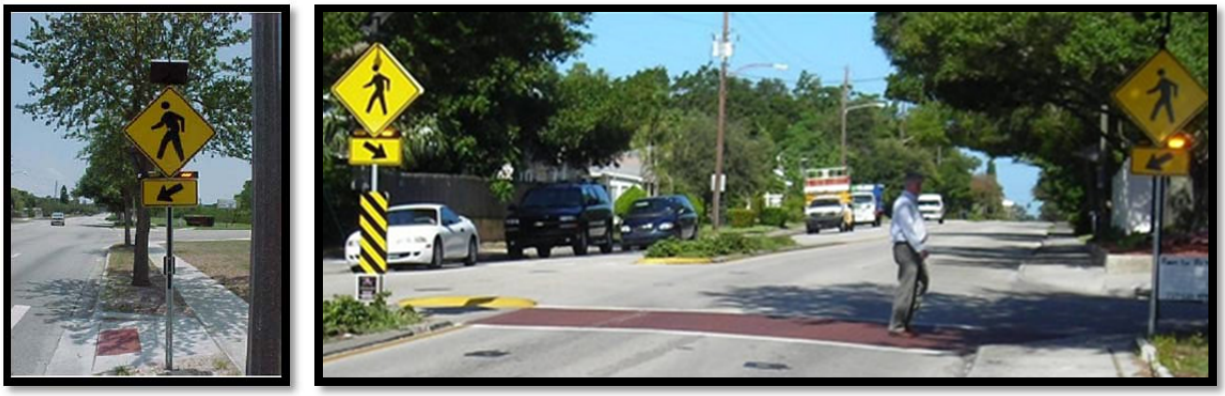
The steady yellow interval should have a minimum duration of 3 seconds and a maximum duration of 6 seconds (see Section 4D.26). The longer intervals should be reserved for use on approaches with higher speeds.

1.7 RECTANGULAR RAPID FLASHING BEACON

Rectangular Rapid Flash Beacons (RRFB) can enhance safety by reducing crashes between vehicles and pedestrians at unsignalized intersections and mid-block pedestrian crossings by increasing driver awareness of potential pedestrian conflicts. RRFBs are a lower cost alternative to traffic signals and pedestrian hybrid beacons that are shown to increase driver yielding behavior at crosswalks significantly when supplementing standard pedestrian crossing warning signs and markings. Additional details can be found at the FHWA site:

http://safety.fhwa.dot.gov/intersection/resources/techsum/fhwasa09009/

Exhibit 1-3 Rectangular Rapid Flashing Beacon



[Images Source: FHWA]

Minnesota has received Blanket Interim Approval from the FHWA to use RRFBs at uncontrolled pedestrian and school crosswalk locations statewide. One of the conditions of approval was that MnDOT keeps a list of all locations where they are installed in the state, whether on State Highways, County Highways, or local roads. If an RRFB is currently installed, or planned for installation, the location of the device must be sent to the MnDOT Office of Traffic, Safety and Technology. The FHWA interim approval website is located at:

http://mutcd.fhwa.dot.gov/res-interim_approvals.htm

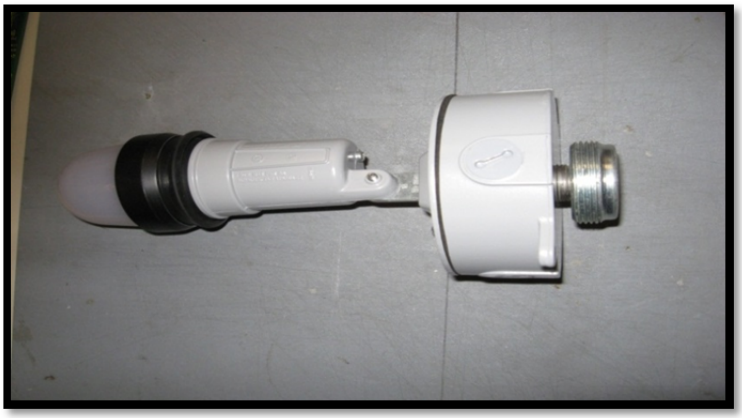
APS push buttons in ADA-compliant locations should be installed with any RRFB. APS push buttons (RRFB Specific APS Pushbuttons) used on an RRFB must be specific to RRFB. APS buttons used at traffic signals or a Pedestrian Hybrid Beacon have different operational features when compared to a RRFB.

1.8 ENFORCEMENT LIGHTS

Enforcement lights are special displays typically placed on an open pole hub or the back side of signal heads for the benefit of an enforcement officer to see when the red is displayed. This allows the enforcement officer to see whether or not a driver has illegally entered the intersection without being on the approach side of the red light. The intent is for only the enforcing officer to see this light. A strategically placed enforcement light will allow the officer to see the stop line, the location of the offending vehicle and the enforcement light simultaneously.

Design of enforcement lights is on a site basis, taking into account where a police officer can safely park to observe the light, be comfortable (no strained neck or views in mirrors) and then safely enter traffic to catch up to the offending vehicle. The enforcement light should never be placed without a field review or simply placing the light on the back side of an approach. The majorities of signalized intersections do not support the use of the enforcement light, mostly because there is no safe place for the police to park and still see the enforcement light. There should never be more than two enforcement lights placed at one intersection. The need for enforcement lights should be supported and pursued by the local police department.

Exhibit 1-4 Enforcement Light



1.8.1 Field Review, Installation Notes and Points

Field review prior to any enforcement light placement is essential for its future use. MnDOT Signal Design staff must meet the police agency at intersections the police desire the light. The police agency should have a list of preferred intersections and approaches at this intersection they believe to have a high potential for red light running and a strategic place for them to park. The enforcement light should not be installed if it may create confusion to the traveling public or will not be used by the police. The field reviews should consider the following:

Strategic and safe place for the police to park to observe the stop line, offending vehicle and enforcement light.

a) Will other traffic such as left turns block the view?
b) Will the officer be comfortable with the view keeping in mind that it could be 3 plus minutes before the next red cycle?
c) Could a second enforcement light be installed and still be viewed from the same location?
d) Will snow build up or soft soil in the winter prevents its use during this time of year?

Other considerations for enforcement light placement.

a) Will the placement of the enforcement light interfere with other indications such as the ped walk or EVP conformation light?
b) Are there available wires for the enforcement light?
c) Signal layout changes must be made.
d) Yellow and all red times should be checked in the controller. Log books should be noted that they were checked and found accurate.
e) Agreement/Memo of Understanding should be written.
f) A background shield behind the light is highly recommended.

1.8.2 Components Used

Several LED lamp arrangements and colors were tested for the enforcement lights. White and blue LEDs were viewed in both darkness and daylight. Both colors appeared to have a noticeable change between on and off in darkness, but proved to be difficult to see an on/off difference in daylight. The white lamp failed to show a difference during daylight while the blue lamp, although somewhat difficult, could be seen in daylight. Compromise must be given for both high lamp brightness which could distract drivers in darkness and not bright enough for enforcement officers to utilize in daylight. MnDOT OTST has a list of preferred components for MnDOT style signal poles.

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2. TRAFFIC SIGNAL PHASING AND OPERATIONS

2.1 INTRODUCTION

The objective of this chapter is to examine the interaction between design and operations. The signal designer must work closely with the signal operator. Decisions on items such as left turn signal phasing are critical to the design steps.

2.2 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.

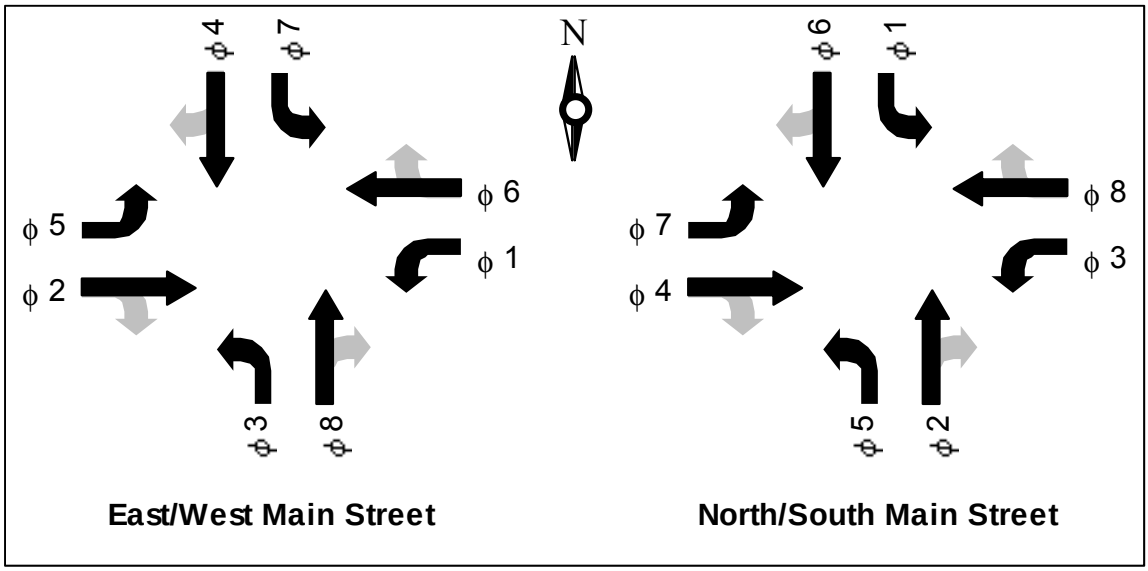
2.2.1 Phase Numbers

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 below), 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.

> It is important for the designer to understand the phase numbers that will be/are used for the intersection. For example, they are used for labeling signal heads during the design process (see Chapter 6).

The figure below shows a typical phase numbering scheme for an east/west arterial and a north/south arterial. MnDOT will typically follow this convention.

Exhibit 2-1 Typical Phase Numbers



2.2.2 Ring

A ring is a term that is used to describe a series of conflicting phases that occur in an established order. A good understanding of the ring structure is a good way to understand the operation of multiphase controllers.

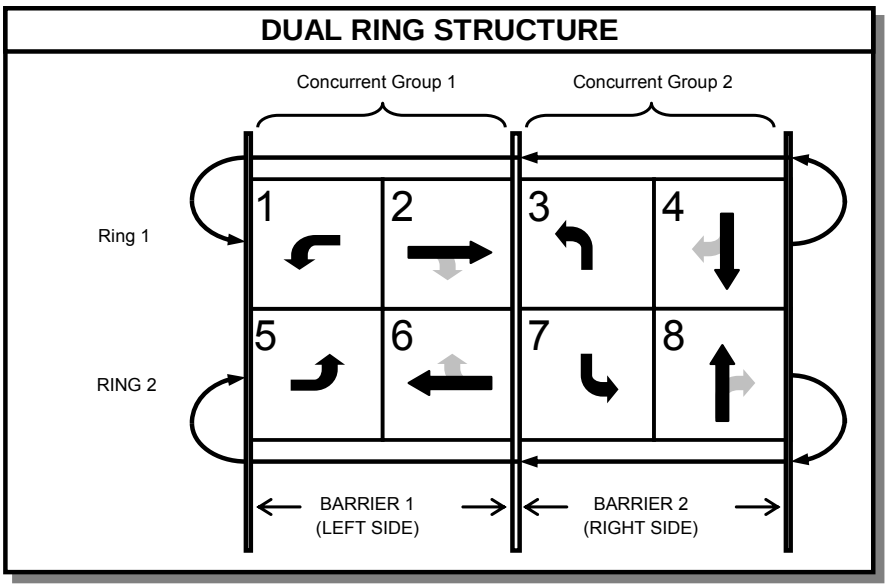
2.2.3 Barrier

A barrier (compatibility line) is a reference point in the preferred sequence of a dual-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.

2.2.4 Dual Ring Control

The traffic actuated controller usually employs a "dual ring concurrent" timing process. The NEMA concept is illustrated in the figure below.

Exhibit 2-2 Dual Ring Structure



Typically, eight phase modules are used on a dual ring controller, each of which controls a single traffic signal head 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. Phases 1, 2, 5 and 6 are defined as Concurrent Group 1. Phases 3,4,7 and 8 are defined as Concurrent Group 2.

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.

Within each Concurrent Group, phases may operate simultaneously vertically (in the ring chart) or may advance diagonally. All Phases in a Concurrent Group must terminate before crossing the barrier into another Concurrent Group.

2.2.5 Overlaps

NEMA Definition: An overlap is a right-of-way indication which allows traffic movement when the right-of-way is assigned to two or more traffic phases. An overlap occurs when one green signal indication is illuminated by more than one phase output from a controller (see the examples shown below).

Exhibit 2-3 Hardwired Right Turn Overlap

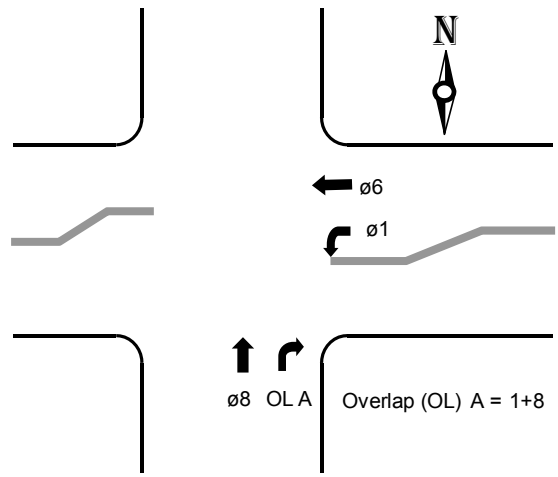
Refer to the image on the right. For the hardwired overlap, the NBR is wired directly with the WBL. For this case, the yellow ball and red clearance is displayed during change from phase 1 to 8. This operation cannot be used if there is a conflicting pedestrian crossing. The hardwired configuration is not typically used by MnDOT.	

Exhibit 2-4 Controller Programmed Overlap

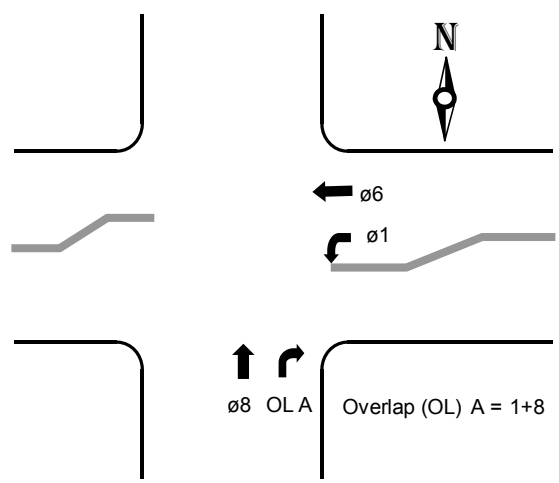
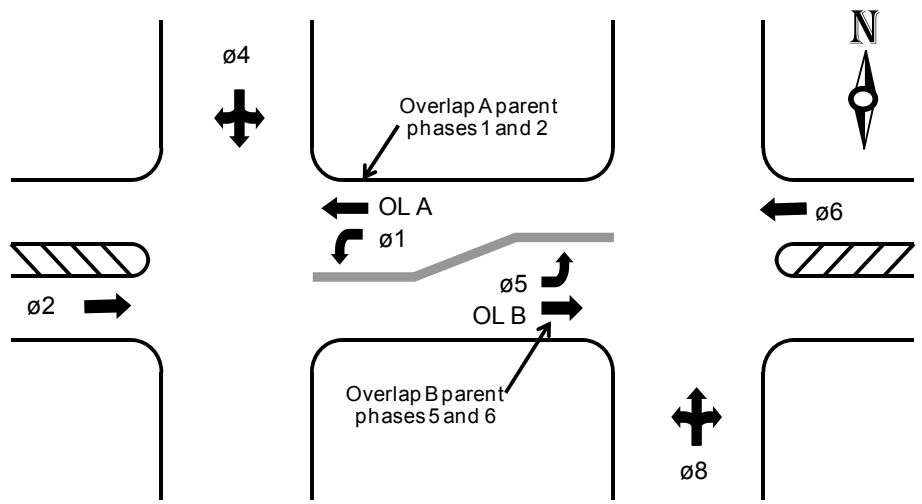
Refer to the image on the right. In this case, the NBR is assigned as overlap A in the controller. The parent phases for OL A are 1 and 8. For this case, the yellow ball and red clearance is NOT displayed and green arrow will continue to be displayed during change from phase 1 to 8. Controller programming can omit the right turn arrow if there is a conflicting pedestrian call.	

Exhibit 2-5 Close Ramp Intersections Using Signal Controller with Overlaps



Refer to the image above. In this case, the WBT at the west ramp is assigned as overlap A in the controller. The parent phases for OL A are 1 and 2.

The EBT at the east ramp is assigned overlap B in the controller. The parent phases for OL B are 5 and 6.

2.3 LEFT TURN PHASE SELECTION

2.3.1 Flashing Yellow Arrow

MnDOT requires the use of FYA for new traffic signal designs with a dedicated left turn lane unless the left turner has limited sight distance. Not only does it fit the requirements of the MN MUTCD for lefts with an exclusive lane, but it also provides flexibility in operation. For example, the FYA can be changed from a permitted only, to protected-only, or protected-permissive on a time of day basis. Therefore, an indication could run protected during times when required and permitted when not. The actual operation is determined by the signal operations staff. For details on operating the FYA, refer to the Signal Optimization and Timing Manual:

> The flashing yellow arrow signal indication is REQUIRED on all new traffic signal dedicated left turn lane approaches on the State trunk highway system unless the left turner has limited intersection sight distance. Refer to Tech Memo 12-10-T-03 (see section **2.3.3**).

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

2.3.2 When Not to Use a Flashing Yellow Arrow

As noted above, the use of a FYA is required whenever permissive left turn operation is allowed. However, the FYA indication should not be used and a protected only indication should be used when the following conditions exist:

- Intersection geometrics creates a **conflicting left turn path**.
- The mainline left turner has limited **sight distance** as defined in the current AASHTO "A Policy on Geometric Design of Highways in Streets."

If there are overlapping paths for the opposing left turns, the plans must indicate that these opposing left turn movements cannot operate together.

Refer to Section **2.5** for MnDOT Selection Guidelines for Traffic Signal Protected Left Turn Phasing (Non Flashing Yellow Arrow).

2.3.3 Flashing Yellow Arrow Tech Memo

The information on the following page is a handout from Technical Memorandum No. 12-10-T-03. The purpose of the technical memorandum is to require the installation of the flashing yellow arrow (FYA) left turn indication on all new traffic signal dedicated left turn lane approaches on the State trunk highway system unless the left turner has limited intersection sight distance (as defined in Chapter 9, Table 9–14 of the 2011 AASHTO "A Policy on Geometric Design of Highways and Streets"), or conflicting (i.e. overlapping) left turn paths are present.

In addition, the FYA informational brochure from the OTST website is included at the end of the tech memo.

MINNESOTA DEPARTMENT OF TRANSPORTATION
Engineering Services Division
Technical Memorandum No. 12-10-T-03
November 28, 2012

To: Electronic Distribution Recipients

From: Jon M. Chiglo, P.E.
Division Director, Engineering Services

Subject: Flashing Yellow Arrow Traffic Signal Indication on MnDOT Trunk Highways

Expiration
This is a new Technical Memorandum and will remain in effect until November 28, 2017 unless it is superseded by a new Technical Memorandum or included in the MnDOT Traffic Engineering Manual.

Implementation
This policy shall be effective immediately.

Introduction
The purpose of this technical memorandum is to require the installation of the flashing yellow arrow (FYA) left turn indication on all new traffic signal dedicated left turn lane approaches on the State trunk highway system unless the left turner has limited intersection sight distance (as defined in Chapter 9, Table 9–14 of the 2011 AASHTO "A Policy on Geometric Design of Highways and Streets"), or conflicting (i.e. overlapping) left turn paths are present.

The National Cooperative Highway Research Program (NCHRP) Report 493 has shown the flashing yellow arrow indication is more understandable and operationally more efficient than traditional protected/permissive left turn indications such as a 5-section indication. MnDOT's experience since the first such installation in 2006 confirms the study results. It has also proved to be significantly more operationally efficient than the protected-only left turn indication. The 2011 Minnesota Manual on Uniform Traffic Control Devices (MnMUTCD), Section 4D.20, explains the definition, placement and operation of the flashing yellow arrow indication. The 2011 MnMUTCD has also changed the head placement for a green ball, which is no longer allowed over the center of a dedicated left turn lane.

The traditional Protected Permissive Left Turn (PPLT) Guidelines are still provided in the 2012 Signal Design Manual for agencies that have not adopted the FYA. When operated properly by time of day, the flashing yellow arrow can be used in many situations where protected-only phasing had been the only operational option. If conflicting left turn paths are present, the signal must be operated in a split-phase operation, and it should be noted on the plan to be sure the signal operator is aware of the conflicting lanes. Documented sight distance issues should also be noted on the plans.

Purpose
To provide additional safety and operational efficiency at traffic signals using a flashing yellow left turn arrow.

Guidelines

Policy
This policy refers to all signals on the trunk highway system. This includes both mainline and cross-street dedicated left turn lanes. A 4-section head using a red arrow, yellow arrow, flashing yellow arrow and green arrow shall be used. Any agency doing work on the trunk highway system shall install the flashing yellow arrow for dedicated left turn lanes on all signal designs for new and reconstructed signal installation with the following exceptions.

- If a sight distance deficiency is documented per definition above, the flashing yellow arrow should not be installed.
- The flashing yellow arrow should not be installed when there are conflicting left turn paths.
- If it has been determined that the signal will run protected only based on engineering judgment related to multiple turn lanes, high volumes and high speeds (all three present), a traditional protected-only 3-section red, yellow, green arrow indication may be used in place of the flashing yellow arrow. If a flashing yellow arrow is not installed based on the above criteria, the system shall be designed to easily accommodate a change to a flashing yellow arrow in the future, including length of mast arm, wiring, cabinet and controller.

If the flashing yellow arrow is not installed at a location because it has conflicting left turn lanes or, a sight distance deficiency, or if there is other information that is important for the signal operator or future signal designer to be aware of, this information shall be provided by the signal designer on the signal plan. Additionally, if conflicting left turns are present, the signal must be operated split phase 24 hours a day or with conflicting left turns as “no serve phases”. If multiple turn lanes and high volumes exist and the posted speed is such that the signal will only be operated in a protected-only phase 24 hours a day, the installation of a protected-only 3-section signal head will be allowed. However, the flashing yellow arrow may still be installed under these conditions and operated in a permissive mode when conditions allow.

Consideration can be given to left turn lanes that have a shared use such as a shared left/thru lane or split-phase operation. This Technical Memorandum does not require the use of a flashing yellow arrow with a shared-use left turn lane or split-phase operations.

Consideration can also be given to existing signal revisions. Costs can be high for retrofitting the flashing yellow arrow into an existing signal; therefore signal revisions do not fall under this Technical Memorandum. Consideration may be given if signal design and operational components support the use of the flashing yellow arrow.

With the flashing yellow arrow indication, left turn operations can vary between protected, protected/permissive and permissive operations by time-of-day programming in the signal controller. It should be noted that, with the flashing yellow arrow, the operator must pay particular attention to how the signal is operated by time of day to achieve the highest level of efficiency and safety. Additional guidelines for the operation can be found in the 2011 MnDOT Traffic Signal Timing and Coordination Manual, page 3-24.

Scope
The policy contained in this technical memorandum applies to MnDOT roadways.

Questions
For information on the technical contents of this memorandum, please contact **Sue Zarling,** Traffic Electrical Systems Engineer at **(651) 234-7052** or **Jerry Kotzenmacher,** Signal Specialist at **(651) 234-7054**.

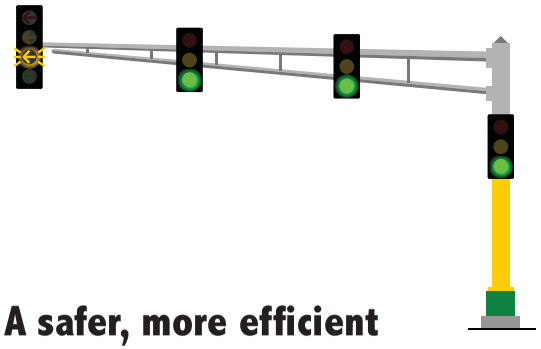
Any questions regarding publication of this Technical Memorandum should be referred to the Design Standards Unit, DesignStandards.DOT@state.mn.us. A link to all active and historical Technical Memoranda can be found at http://techmemos.dot.state.mn.us/techmemo.aspx.

To add, remove, or change your name on the Technical Memoranda mailing list, please visit the web page http://techmemos.dot.state.mn.us/subscribe.aspx

HANDOUT

A safer, more efficient left-turn signal

HANDOUT



A safer, more efficient left-turn signal

Safer

A national study demonstrated that drivers found flashing yellow left-turn arrows more understandable than traditional yield-on-green indications (individual traffic signal lights).

Less delay

There are more opportunities to make a left turn with the flashing yellow left-turn arrow than with the traditional three-arrow, red, yellow and green indications.

More flexibility

The new traffic signals provide traffic engineers with more options to handle variable traffic volumes..

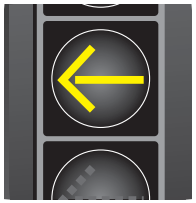
Minnesota Department of Transportation
Office of Traffic, Safety and Technology
1500 West County Road B2
Roseville, MN 55113
Jerry Kotzenmacher
Phone: 651-234-7054

E-mail: jerry.kotzenmacher@state.mn.us

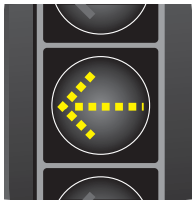
HANDOUT

What the arrows mean

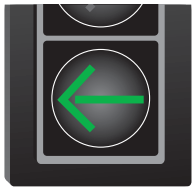
Solid red arrow:
Drivers intending to turn left must stop and wait. They should not enter an intersection to turn when a solid red arrow is being displayed.



Solid yellow arrow:
The left-turn signal is about to change to red and drivers should prepare to stop or prepare to complete a left turn if they are legally within the intersection and there is no conflicting traffic present.



Flashing yellow arrow:
Drivers are allowed to turn left after yielding to all oncoming traffic and to any pedestrians in the crosswalk. Oncoming traffic has a green light. Drivers must wait for a safe gap in oncoming traffic before turning.



Solid green arrow:
Left turns have the right of way. Oncoming traffic has a red light.

Flashing yellow arrow benefits

A flashing yellow arrow signal has the same meaning it always has: left turns may proceed with caution after yielding to oncoming traffic.

In the past, flashing yellow arrows in Minnesota were only used when the entire traffic signal was in flash-mode. Use of the flashing yellow arrow has been shown to have several benefits including minimizing delays and enhancing safety by reducing driver errors. Flashing yellow arrow signals have been approved for widespread use by the Federal Highway Administration..

Where will the flashing yellow arrow be used?

The majority of newly installed MnDOT traffic signals will have the flashing yellow arrow option. The flashing yellow arrow may be used at any intersection at any time but the most typical use will be at intersections and times-of-day that have lower volumes, lower speeds and other favorable conditions.

A better left-turn signal

Flashing yellow arrow signals have been shown to help drivers make fewer mistakes. They keep motorists safer during heavy traffic and reduce delays when traffic is light.

Your Destination...Our Priority

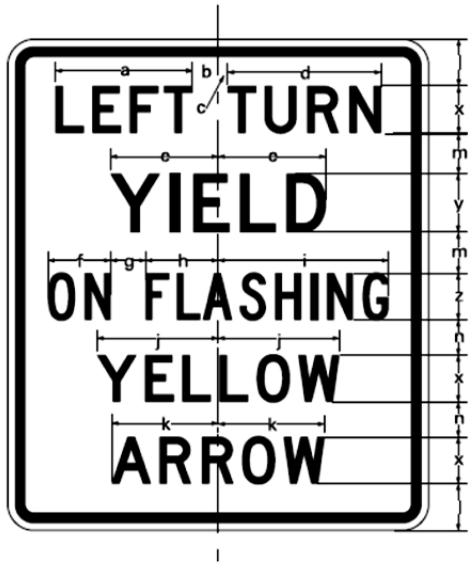
2.3.4 Flashing Yellow Arrow Signing

For FYA installations, an R10-X12 sign will be installed for a minimum of 6 months. After this time, the sign can be removed by the district traffic engineer or left up for its useful life.

Exhibit 2-6 Left Turn Yield on Flashing Yellow Sign

SIZE / DIMENSION	36 X 42	42 X 48	
RADIUS	2.25	2.25	
MARGIN	.63	.63	
BORDER	.88	.88	
a	11.7	14.6	
b	2.2	2.9	
c	.8	1.1	
d	13.1	16.4	
e	9.2	11.1	
f	5.4	6.7	
g	3	3.5	
h	6.2	7.9	
i	14.6	18.1	
j	10.4	13	
k	9.1	11.4	
l	4	4.5	
m	3.5	3.5	
n	3	3	
o			
p			
q			
r			
s			
t			
u			
v			
w			
x	4D	5D	
y	5D	6D	
z	4C	5C	

NOTES: 1. All dimensions are in inches.
2. Color - Black legend and border on white reflectorized background.



LEFT TURN YIELD ON FLASHING YELLOW		
APPROVED	DATE OF REV.	SIGN NUMBER
8/21/06	1/1/11	R10-X12

In the Metro District, the larger 42” x 48” sign will always be used for all locations. In all other districts, use the 36’’ x 42’’ for 2-lane roadways and the 42” x 48” on a 4-lane (or more) roadway.

2.3.5 Flashing Yellow Arrow and Retrofits

The following handout is a printout of a spreadsheet used to estimate the cost of retrofitting an existing traffic signal with flashing yellow arrow indications. This spreadsheet is available from OTST and is used to evaluate the feasibility of the retrofit.

When designing a retrofit FYA for an exclusive left turn, attempt to place the new FYA as close to the center of the exclusive left as possible. When this is not feasible, the FYA can be located in a location other than the center of the turn lane. Use engineering judgment to determine this offset amount (2’ from center is generally acceptable, more in certain cases). Note that this indication must be no closer than 8’ from any adjacent signal head based on MN MUTCD requirements.

FYA Retrofit Assessment

Form updated 4/25/2013

Intersection	

Requested by		on behalf of	
	Name of person		Name of agency

Listed in square brackets after each heading is the functional area responsible for completing that section of the assessment. Please complete and save the assessment in Excel rather than writing on a hard copy.

CESU = Central Electrical Services Unit
MESU = Metro Electrical Services Unit
RESU = Regional Electrical Services Unit

1. System info [Signal Operations]

Name of person completing this section	Date

System ID		TE #	
Age of system (years)		R/R preemption?	

	NORTHBOUND Enter road name or "-" if none	SOUTHBOUND Enter road name or "-" if none	EASTBOUND Enter road name or "-" if none	WESTBOUND Enter road name or "-" if none
Pole # for overhead indications				
Phase # for through phase				
Phase # for left-turn phase				
Existing left turn phasing (before retrofit)				

Is there any other signal work going on at this intersection at this time?.....

If Yes, provide details:

Comments Within comments field, hit Alt+Enter to start a new line.

2. Mast arms and heads [Signal Design]

Name of person completing this section	Date

*It may be helpful to create a redline layout while filling out Section 2, 3 and 4, as it will also be required for the TE Request.

All prices are estimated furnish and install (including miscellaneous removals).

	NORTHBOUND Enter road name or "-" if none	SOUTHBOUND Enter road name or "-" if none	EASTBOUND Enter road name or "-" if none	WESTBOUND Enter road name or "-" if none
2A. MAST ARMS, POLES, AND FOUNDATIONS				
Do mast arms need to be replaced?				
Estimated cost for each direction, including removals *Use costs from Signal Design Cost Estimate Templete.*				
Do mast arms need 5-foot extensions?				
Estimated cost for each extension *Use $700 per extension*	$ 0	$ 0	$ 0	$ 0
Do poles and foundations need to be replaced?				
Estimated cost for each direction, including removals				
2B. NEW FYA SIGNAL HEADS				
How many?				
Estimated cost for each direction *Use $1,700 per signal head (includes cost of wiring from base of pole to head plus connectors and new mount)*	$ 0	$ 0	$ 0	$ 0
2C. NEW SIGNAL HEADS OTHER THAN FYA				
How many?				
Estimated cost for each direction				
2D. EXISTING SIGNAL HEADS NEEDING TO BE MOVED TO A DIFFERENT POINT ON MAST ARM				
How many?				
Estimated cost for each direction				
2E. SIGN (LEFT TURN YIELD ON FLASHING YELLOW ARROW)				
How many?				
Estimated cost for each direction *Use $400 per sign*	$ 0	$ 0	$ 0	$ 0
2F. EXISTING EVP EQUIPMENT (DETECTOR AND/OR CONFIRMATION LAMP) ON MAST ARM				
Will EVP equipment on mast arm need to be moved or provided with a vertical extension due to a lack of space on mast arm with FYA sign?				
Estimated cost for each direction				

Comments Within comments field, hit Alt+Enter to start a new line.

Section 2 estimated cost subtotal **$ 0**

3. Wiring and conduit [Signal Design]

Name of person completing this section	Date

All prices are estimated furnish and install (including miscellaneous removals).

3A. CABLE FROM CABINET TO POLE BASE	NORTHBOUND Enter road name or "-" if none	SOUTHBOUND Enter road name or "-" if none	EASTBOUND Enter road name or "-" if none	WESTBOUND Enter road name or "-" if none
Are there spare wires in the pole base sufficient for FYA? *-keep in mind that additional spares need to be maintained for emergencies*				
If no, what is the estimated cost to run new cable from cabinet to pole base:				
3B. CONDUIT				
If additional cable needs to be pulled through the conduit, are underground conduits already at capacity?				
If yes, what is the estimated cost to bore new conduit from cabinet to pole base:				

Comments *Within comments field, hit Alt+Enter to start a new line.*

Section 3 estimated cost subtotal	**$ 0**

4. Loop Detectors [Signal Design]

Name of person completing this section	Date

All prices are estimated furnish and install (including miscellaneous removals).

4A. LOOP DETECTION	NORTHBOUND Enter road name or "-" if none	SOUTHBOUND Enter road name or "-" if none	EASTBOUND Enter road name or "-" if none	WESTBOUND Enter road name or "-" if none
Is existing detection adequate for FYA?				
If no, number of new loop detectors needed:				
Estimated cost for new loop detectors: *Use $1,000 per new milled detector.*	$ 0	$ 0	$ 0	$ 0
4B. LEAD-IN COST				
Are lead-ins needed?				
If Yes, what is the estimated cost for new lead-ins:				

Comments Within comments field, hit Alt+Enter to start a new line.

Section 4 estimated cost subtotal **$ 0**

5. Cabinet and controller [CESU]

Name of person completing this section | Date

		MATERIALS COST	ESTIMATED LABOR HOURS	
			HST	ET
5A. Cabinet number				
5B. Existing cabinet type				
5C. Can the cabinet be modified entirely in the field?				
			ET	
Will the cabinet need to be replaced with a new TS2 cabinet or refurbished TS1 cabinet				
5D. Existing load switch socket count				
5E. How many load switches are currently in use?				
5F. How many load switches are currently open?				
5G. Add load switches?		$ 0		
Number of new load switches at $25.75 each.				
5H. Modify/add detector amps?				
5I. Existing controller type?				
5J. Will controller need to be replaced for FYA?				
5K. Is new MMU required for FYA?				

	HST	ET
Total labor hours:	0	0
Hourly rate of pay:	$40.82	$37.77
Labor pay:	$0.00	$0.00

5L. Cabinet print revision		$0.00
5M. Shop supplies		
5N. Transportation	$ 0	

Distance to job site (one-way)		miles
Estimated round trips required		round trips
Total mileage	0	miles
Cost per mile	$0.69	per mile

Estimated totals for cabinet and controller modifications (CESU)	$ 0	$0
	Materials costs	Labor costs

Cabinet and controller comments Within comments field, hit Alt+Enter to start a new line.

Section 5 estimated cost subtotal $ 0

6. Installation cost for new TS2 or refurbished TS1 cabinet [Contractor or MESU]

6A. Estimated cost for new TS2 or refurbished TS1 cabinet installation by contractor or MESU, if any.

Estimated cost for cabinet installation by contractor, includes salvaging old cabinet to CESU *Use $2,000 per intersection*	$ 0

Comments Within comments field, hit Alt+Enter to start a new line.

Section 6 estimated cost subtotal	**$ 0**

7. Estimated total costs [Signal Operations]

Name of person completing this section	Date

7A. Estimated cost for items furnished and/or installed by contractor or State..... $ 0
Sum of costs in sections 2, 3, 4, and 6.

7B. Estimated cost for mobilization..... $ 0
Mobilization is taken to be 6% of the estimated cost for items furnished and/or installed by contractor.

7C. Estimated cost for E + I (engineering and inspection)..... $ 0
E + I is taken to be 8% of the estimated cost for items furnished and/or installed by contractor.

7D. Estimated cost for traffic control while signal revision takes place..... $ 0
An estimated traffic control cost of $2,000 will be assumed for every intersection.

7E. Estimated cost for cabinet/controller related items furnished and/or installed by State..... $ 0
Sum of materials and labor costs from section 5.

7F. Estimated total cost for FYA retrofit..... **$ 0**

Overall comments Within comments field, hit Alt+Enter to start a new line.

2.3.6 Flashing Yellow Arrow Summary

In the past, the operation of the left turn phase was determined during the design process. This was based on the legacy criteria detailed in Section **2.5**. One issue is that a protected only left turn phase may have been needed for one hour in the day. If a protected only left turn indication was designed, it was a static operation and would need to run in this mode 24-hours per day.

For new designs, per Technical Memorandum No. 12-10-T-03, the designer is required to use a FYA indication at dedicated left turns with the exceptions noted in the tech memo. The actual operation of the left turn phase is now flexible and can vary between protected-only, protected-permissive or permissive only on a time-of-day (TOD) basis. Therefore, a left turn could operate during one period as protected-only when required for volumes, and permissive when not required.

2.4 FLASHING YELLOW ARROWS FOR RIGHT TURNS

In Sections 4D.21 through 4D.24 of the MN MUTCD, information on signal indications for right turn movements is provided. Section 4D.21 states:

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

Refer to the MN MUTCD handout at the back of chapter 3 for full details on the variety of options for right turns.

2.5 MNDOT SELECTION GUIDELINES FOR TRAFFIC SIGNAL PROTECTED LEFT TURN PHASING (NON FLASHING YELLOW ARROW)

The information in this section is used for the selection of a left turn signal indication when the designer is **not** using a flashing yellow arrow (FYA) indication (see page 2-5). Investigating the use of a FYA indication is encouraged since it allows greater flexibility in the signal operations. For instance, a FYA can change from a protected-only, to protected-permissive or permissive only on a time of day (TOD) basis. A traditional protected-only signal operation cannot be changed on a TOD basis.

These guidelines are intended for locations were a FYA indication is not being considered for use. However, using a FYA is required for new installations on state highways and encouraged at other locations throughout Minnesota.

Of additional importance is the language in section 4D.13 of the Mn MUTCD that states:

> *"For new or reconstructed signal installations, on an approach with an exclusive turn lane(s) for a left-turn (or Uturn 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 signal head placement charts in Chapter 3 reflect this requirement. Therefore, any signal head centered over or directly in front of an exclusive left turn lane must be a FYA or protected-only indication. It cannot have a circular green indication for permissive left turn movements.

2.5.1 Introduction

In the past, the operation of the left turn movement was determined by the signal designer. The type of signal head selected controlled the operation of the movement (protected, permissive, protected-permissive or split). As previously noted, MnDOT requires the use of the FYA head on state highways (with the exceptions listed in Technical Memorandum No. 12-10-T-03) and the operation is determined by the signal operator.

When designing a left turn movement without the use of the FYA, the correct type of left turn phasing used at signalized intersections is a critical component for safe and efficient operation. In many cases the left turn selection process can be difficult when there are special concerns or gray areas. In all cases, if a protected-only left turn is selected, the intesection cannot vary the operation on a time-of-day basis as can the FYA.

Permissive or protected-permissive left turn operation is usually the most efficient. However, when the driver is placed in difficult decision or risk taking situations, the protected only left turn operation can increase safety. Inversely, drivers lose respect for protected only left turn signals when they can obviously make their own safe decision to turn on a gap. Enhanced signal detection, sequencing, and timing can reduce delay associated with protected only phasing.

If not using a FYA, the signal designer must also be aware of the effects to special operations such as Emergency Vehicle Preemption and system coordination. Every intersection is unique; situations not defined in the guidelines, such as Emergency Vehicle Preemption (EVP), pedestrian conflicts, geometric constraints, a high proportion of trucks, and existing left turn performance as observed in the field may influence the choice of left turn phasing in favor of safety.

The following guidelines do not address split phasing, where the left turn and through phase run simultaneously for one approach, and then for the opposite approach.

The aim of these guidelines is to establish an uncomplicated selection process that can be used as a starting point for determining the proper type of left turn phasing **if not using FYA**. Engineering judgment is still required taking into account the specific conditions at the site.

2.5.2 Left Turn Protected Phasing Selection Guidelines

This guidelines section provides a starting reference point for determining the left turn operation at an intersection. Engineering judgment and site-specific considerations of safety and efficiency may cause deviations from the operation indicated by these guidelines. Other issues to consider in evaluating phasing include geometric constraints, pedestrian conflicts, special emergency vehicle treatments, intersection delay, older drivers, human factors, a high proportion of trucks, and existing left turn performance as observed in the field.

This section first discusses the need for left turn phasing followed by criteria for protected only operation. Terms, definitions and additional phasing guidance clarifies terms used throughout the guideline, each term presented is shown in the discussion in bold text.

Need and design guide for a Left Turn Phase:

Before using the guidelines below to evaluate **protected only** or **protected/permissive** left turn operation, the signal designer should perform an analysis to determine the need for a separate left turn phase. This analysis may utilize the methodology described in the Highway Capacity Manual produced by the Transportation Research Board, based upon geometrics, speeds, volumes, volume cross products, and other factors, which analyzes intersection performance in terms of measures such as volume to capacity ratio and level of service. Simulation software is also useful in evaluating candidate left turn phasing.

Left turn lane alignment should be designed considering operation and visibility for left turning vehicles (refer to Section **2.6** regarding Left-Turn Lateral Offset). Median treatment for the entire road segment can be beneficial and outweigh the development of fully aligned left turn lanes along major high volume highways.

Protected Only Guidelines: Protected only left turn phasing is recommended for the following conditions:

- When **railroad preemption** is used and the movement is opposite the track clearance movement or turns across the tracks unless other measures are implements to address this conflict.
- **Lead-lag left turn sequence** is utilized.
- Intersection geometrics creates a **conflicting left turn path**.
- The left turner faces three or more **opposing through lanes**.
- The mainline left turner has limited **sight distance** as defined in the current AASHTO "A Policy on Geometric Design of Highways in Streets."
- Protected/permissive operation is in place and there are 5 or more **left turn related collisions** per year over a 3-year period susceptible to correction by protected only phasing.
- Mainline has **dual left turn lanes**.
- **Speed** 45 MPH or greater AND
- Peak hour left turn volume greater than 240 vehicles or peak hour **cross product** greater than 80,000 (100,000 if 2 opposing lanes).

2.5.3 Terms, Definitions and additional Phasing Guidance Discussion

Protected only left turn operation: signal phasing that allows left turn movements to only be made on an exclusive phase (green arrow).

Protected/permissive left turn operation: signal phasing that provides an exclusive phase (green arrow) followed by a permissive phase, time during the signal cycle where left turning traffic may make a left turn after yielding to oncoming traffic.

Left Turn Lane Alignment: Left turn lanes that are aligned directly across from each other (head on) work best for permissive left turns since the driver can more easily see around the opposing left turning vehicle and look for a safe gap in traffic. Directly aligned opposing left turn lanes (double yellow across from a white left turn lane line) would be considered to have a zero foot offset. For medians, the measurement would be made laterally from the center of the left turn lane to the center of the opposing left turn lane. The left turn lane alignment guideline is not applicable where there are no opposing left turns, such as with a 1 way cross street or at a "T" intersection. The closer the left turning vehicle is to being left of the opposing left turning vehicle, the greater the visibility.

Railroad Preemption: **Railroad Preemption.** Protected-only operation should be implemented for two types of left turn movements, as described below, at signalized intersections with railroad preemption, unless other reasonable accommodations can be made.

1. The first left turn movement to be considered for protected-only operation is the <u>left turn which opposes and conflicts with the track clearance phase</u>(s), e.g., the westbound left turn when the track clearance interval clears eastbound traffic with a green ball and arrow. If that left turn movement is protected-permissive or permissive-only, the potential exists for a left turn trap scenario. Protected-only service for that movement eliminates that possibility. Assuming sufficient railroad warning time is available, a reasonable alternative to protected-only service for that movement is to set up the railroad preemption sequence such that all phases – including the track clearance phase(s) – are terminated immediately prior to activating the track clearance interval.
2. The second left turn movement to be considered for protected-only operation is a <u>left turn which crosses the tracks as it departs the intersection</u>, e.g., a northbound left turn crossing tracks located on the west side of and parallel to a north-south roadway. If that left turn movement is protected-permissive or permissive-only, the potential exists for a vehicle to be struck by a train as the vehicle crosses the tracks. With protected-only operation, the phase for that left turn movement can be omitted (red left arrow displayed) for the duration of the railroad preemption. A reasonable alternative to protected-only service for that movement is the installation of a blank-out sign (R3-2a in the Minnesota MUTCD) which is normally blank but which is activated by the railroad preemption system to display the message “NO LEFT TURN ACROSS TRACKS”.

Lead-Lag Turn Sequence: A lead-lag left turn phasing sequence can benefit progression within coordinated traffic control signal systems. However, to avoid a left turn trap scenario, a protected only operation should serve the left turn movement, which opposes the through movements served during the lagging left turn phase.

Conflicting Left Turn Paths: At some locations geometric constraints at the intersection cause the paths of opposing left turn vehicles to cross as overlap creating a conflict. An example is an approach that crosses a divided roadway with a wide median. In these locations, it may be necessary to operate the left turns in a lead-lag sequence or a split phase sequence, not allowing simultaneous opposing left turns. This operation will require protected left turns.

Opposing through lane (conflict): The opposing through lanes are the lanes across from, and in conflict with, the left turning vehicle. Multiple lanes make it difficult for a driver to evaluate gaps in oncoming traffic. An opposing separate right turn lane will typically not be counted with opposing through lanes unless engineering judgment indicates that the lane configuration and number of right turns will cause conflicts with the left turn movement.

Limited Sight Distance (Requirements)**:** The minimum sight distance values necessary for the design vehicle volume to complete the turn movement. Distance should be calculated from the stop bar for the mainline left turning vehicle. Measurement is based on travel path, speed, and acceleration vehicle height. Both the sight distance for passenger vehicles and trucks should be checked using heights and distance requirements per the AASHTO Geometric Design Guide. The current reference at time this manual was prepared is the 2004 Guide, Chapter 9, Exhibit 9-67).

Left Turn Related Collisions:. These are accidents Collisions that could be corrected by protected only phasing, such as those between are those involving a left turning vehicle and opposing through vehicle. The number of accidents is consistent with the traffic signal accident warrant requirements. At higher speeds the accidents collisions are likely to be more severe. Therefore, a lower number of collisions are used as the parameter for consideration for high-speed approaches. Because of the variations in collisions overtime, an average number of collisions per year over a 3- year period should be used if the data is available.

At locations meeting the accident collisions numbers for protected only phasing, but where there is no existing signal or where there is an existing signal with permissive only left turns, an agency may desire to install protected/permissive phasing prior to installing protected only phasing. A follow-up study should be conducted to evaluate the changes based on the collision criteria.

Dual Left Turn Lanes: Multiple left turn lanes may consist of exclusive left turn lanes or a combination of exclusive left turn lanes and lanes that are shared by through and left turning traffic. Both the dual lane and the left turn lane opposing this operation are recommended to operate with protected phasing provided. Left turn lanes without opposing traffic, such as left turns off of a one- way street, does not require protected only phasing based upon this criteria.

Speed: Because it can be difficult for a driver to accurately judge available gaps in traffic approaching at high speeds, the engineer must exercise extreme discretion when considering permissive or protected permissive left turn phasing with opposing speeds of 45 MPH or above.

Use of posted speed limit is recommended. Non-arterial approaches may have lower speeds than the posted speed limit because they are often in a stop condition upon the arrival of traffic. Grades affect the acceleration rate of the left turner and the stopping distance and speed of the opposing through traffic and are therefore considered in conjunction with speeds.

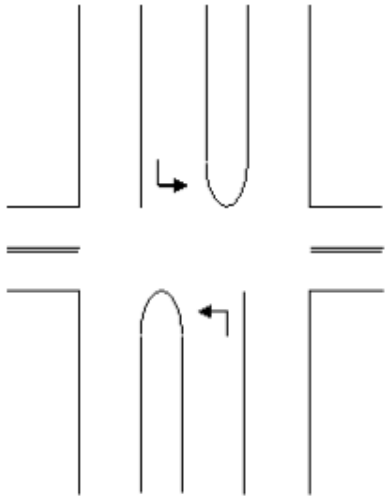
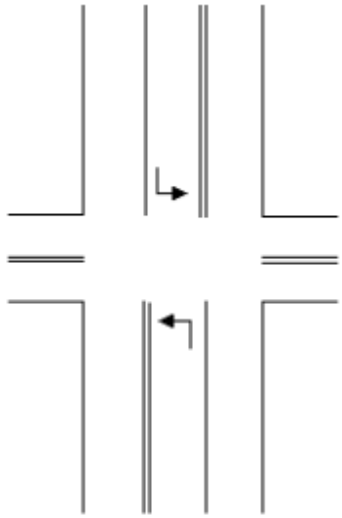
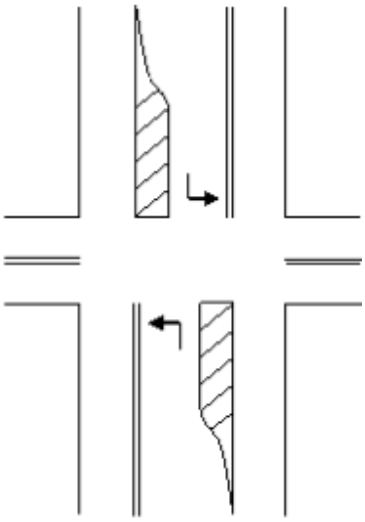
Cross Product: The left turn volume multiplied by the opposing through volume. The cross product values used in the Combination of Protected Only Guidelines are taken from the Wisconsin Department of Transportation (WisDOT) Traffic Signal Design Manual discussion on left turn conflicts analysis, Chapter 2, Section 3, Subject 4. Cross product used represents a high frequency of conflicts for left turners looking for gaps in through traffic.

2.6 LEFT-TURN LATERAL OFFSET

Sight distance is important for drivers to identify acceptable gaps in opposing traffic. Opposing left-turn lanes are typically aligned directly across from one another and immediately adjacent to the through lanes. Thus, a left-turning vehicle in the left-turn lane can obstruct the view of oncoming vehicles, particularly those in the opposite left-turn lane.

To improve sight distance and safety for left-turning drivers at intersections, the use of offset left-turn lanes has been recommended, as discussed in the NCHRP Report 500 Series Volume 12, "A Guide for Reducing Collisions at Signalized Intersections." Sight distance for left-turning vehicles is diminished with a negative offset or, to a lesser degree, no offset. Sight distance can be improved by shifting left-turn lanes to the left to create a positive offset.

Exhibit 2-7 Left Turn Lane Lateral Offsets

Negative Offset	No Offset	Positive Offset
		
		

2.6.1 Flashing Yellow Arrow Permissive Operations

This issue of lateral offset for left-turning vehicles is importance with the widespread installation of the flashing yellow arrow (FYA) left turn indication. The FYA allows traffic signal operators to change left-turn phasing by time-of day (i.e. a left turn could run protected during the peak hour but permissive during the off-peak hours).

A positive left-turn lateral offset would help FYA signalized intersections both more safely and efficiently with this changing left-turn operation by time-of-day.

2.7 SIGNAL OPERATIONS

The information following this sheet is a handout taken from MnDOT's Traffic Signal Timing and Coordination Manual, May 2013.

The most current version of the Traffic Signal Timing and Coordination Manual can be found at:

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

Note: It is recommended that you review all original reference material.

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:

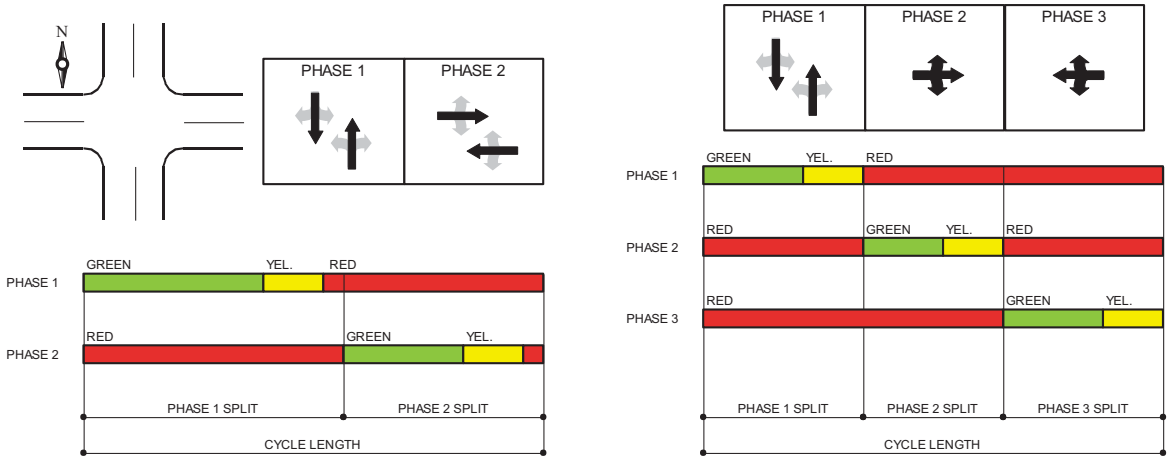
- ✓ Simplicity of equipment provides relatively easy servicing and maintenance.
- ✓ Can be coordinated to provide continuous flow of traffic at a given speed along a particular route, thus providing positive speed control.
- ✓ Timing is easily adjusted in the field.
- ✓ Under certain conditions can be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

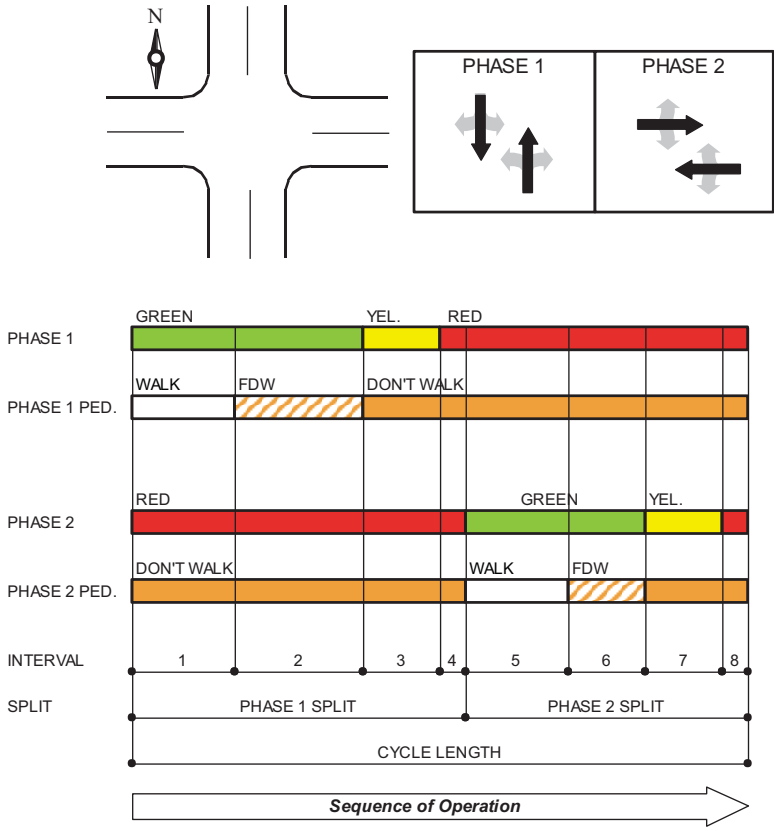
Traffic Signal Phasing

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

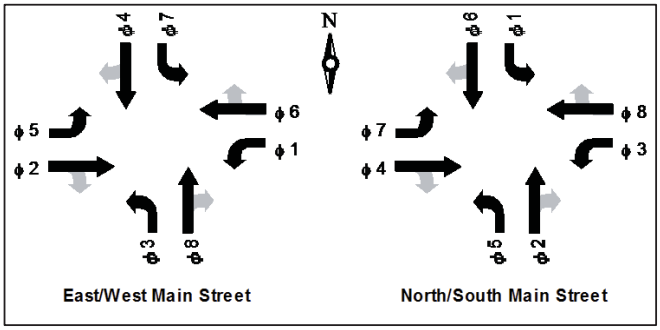
A barrier (compatibility line) is a reference point in the preferred sequence of a multi-ring controller unit at which all rings are interlocked. Barriers assure there will be no concurrent selection and timing of conflicting phases for traffic movements in different rings. All rings cross the barrier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

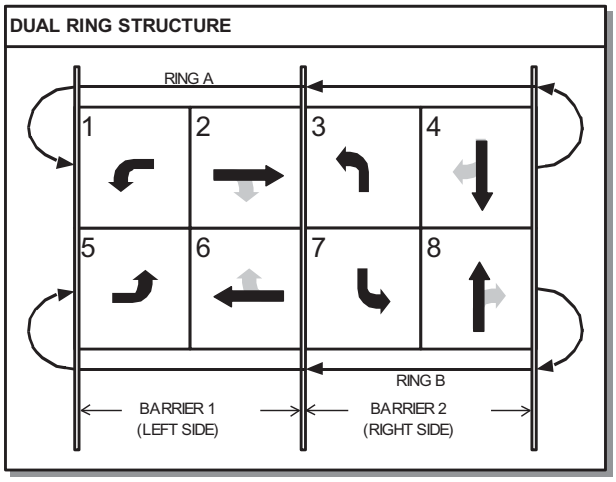
Exhibit 3-3 Common Phase Numbering Scheme



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).

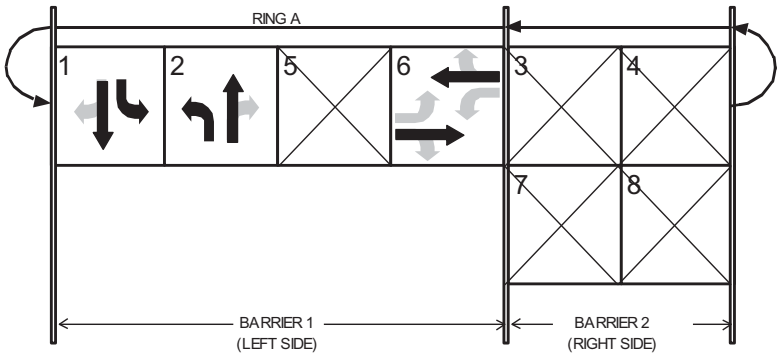
Modern controllers offer more flexibility in assigning traffic signal phases in order to control many complex or unique situations. TS2 controllers include four timing rings and up to sixteen vehicle phases and sixteen pedestrian phases. Each phase can be assigned to any ring. In addition, there are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

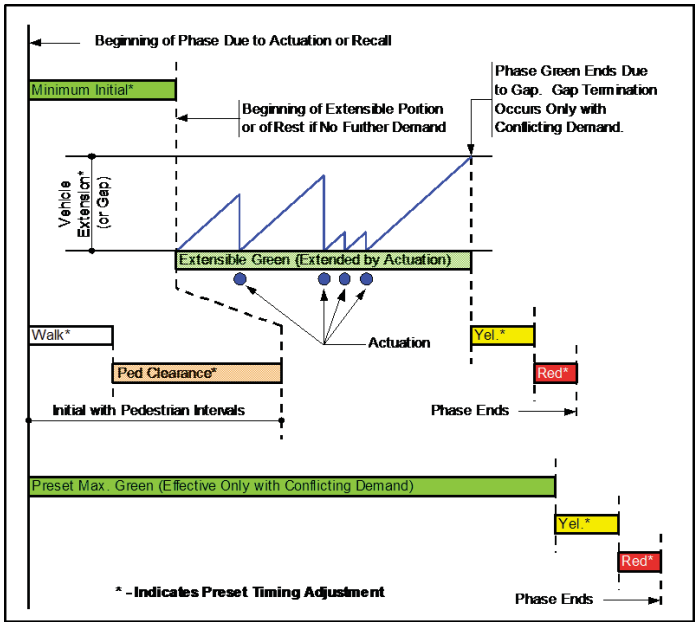
	Barrier 1				Barrier 2				Barrier 3				Barrier 4			
Ring 1	Phase 1	Phase 2			Phase 3	Phase 4			Phase 9	Phase 10			Phase 11	Phase 12		
Ring 2	Phase 5	Phase 6			Phase 7	Phase 8			Phase 13	Phase 14			Phase 15	Phase 16		
Ring 3																
Ring 4																

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.

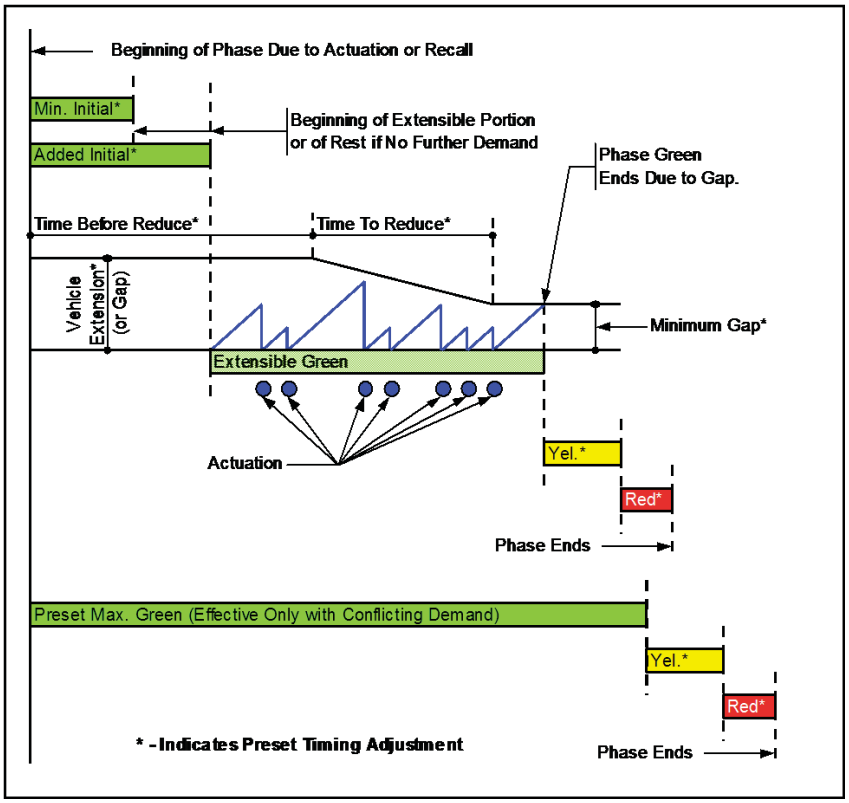
Volume Density Control

Even more sophisticated operation is possible with the volume density traffic actuated controller unit. In addition to the features discussed above, volume density provides two means of modifying the basic timing intervals. These are:

- ✓ *Variable initial* is a means of extending the initial portion of the green interval. This is done on the basis of the number of actuations above a preset number while the phase is displaying yellow or red. This extended initial provides additional green time for a queue of vehicles waiting, when the green signal appears, to clear the intersection if the detectors are set back a distance from the stop bar and there are no vehicles following.
- ✓ *Gap reduction* is a means of reducing the passage time or gap on the basis of the time that opposing vehicles have waited. In effect, it benefits the waiting vehicles by reducing the time allowed between vehicles arriving on the green phase before that phase is terminated.

The timing diagram for a volume density phase is shown in Exhibit 3-8.

Exhibit 3-8 Volume-Density Timing Diagram



Gap Reduction

Gap reduction, as the name implies, reduces the gap or allowable headways between vehicles from the original value (MAX GAP) to a lesser value (the MIN GAP) over a specified amount of time.

While gap reduction is used sporadically in the field, it can be a valuable tool. For example, assume there is an approach to a fully actuated intersection that experiences a very sluggish "start-up" creating excessive

4 LOCAL INTERSECTION TIMING

4.1 Timing Practices

Assuming that the traffic control signal has been designed and installed in accordance with good technical practices, proper timing is the final ingredient to create an efficiently operating traffic control signal. The objective of signal timing is to alternate the right of way between traffic streams so that average total delays to all vehicles and pedestrians, and that the possibility of crash-producing conflicts are minimized.

The purpose of this manual is to establish uniform guidelines for MnDOT personnel to time traffic control signals. It is intended to set forth accepted practices, procedures and guidelines. It should be noted that there are no legal requirements for the use of these practices, procedures and guidelines. The legal considerations are set forth in the state law and the Minnesota Manual on Uniform Traffic Control Devices (MN MUTCD).

It should also be noted that these guidelines, procedures and practices are general and should be used only as a general guide. Many other factors at each individual intersection must be considered and good engineering judgment must be utilized in applying these guidelines. Field observations and timing adjustments must be done to maximize the efficiency and safety of the traffic control signal operation. A series of timing adjustments may be necessary.

The timing values developed through these procedures may not in all cases be directly set on all traffic control signal controllers. Each manufacturer may have a different way of timing each timing function. Care must be taken in knowing the theory of operation of each traffic control signal controller and setting values in the traffic signal controller.

There are basically two types of traffic signal controllers; pre-timed (fixed timed) and traffic actuated (variably timed). The guidelines, procedures and practices apply more directly to traffic actuated controllers, because the majority of MnDOT's controllers are the traffic actuated type.

Traffic control signal controllers can be operated in a free (isolated) or a coordinated (system) mode of operation. This section of this guideline will address the free (isolated) mode of operation.

In timing a traffic signal, a good understanding of the meaning of the signal indications is necessary. The meaning of signal and pedestrian indications can be found in the MN MUTCD in Section 4D.

4.2 Full Traffic Actuated Timing Controls

The following are basic timing parameters that are necessary for a traffic signal controller to operate. These guidelines, procedures and practices are based on them. MnDOT uses microprocessor controllers manufactured to NEMA, TS2-type2 standards. There are other functions and parameters that need to be installed on each particular manufacturer controllers. Each manufacturer's traffic controller manual should be reviewed and understood before operating the controller in a field application. Any questions as to using these other functions or parameters should be directed to the Traffic Signal Engineer.

1. WALK - Establishes the length of the WALK interval.
2. PEDESTRIAN CLEARANCE (CHANGE) - Establishes the length of flashing DON'T WALK interval.
3. MINIMUM GREEN - Establishes the length of initial state of green interval.
4. ADDED INITIAL - Density feature. Establishes number of seconds by which each vehicle (actuation) builds added initial state of green during non-green time on phase.

5. PASSAGE TIME - Establishes the increment of right of way (green) time extension for each vehicle actuation during the green interval.
6. TIME BEFORE REDUCTION - Density feature. Establishes a preset time before allowed gap begins to reduce.
7. TIME TO REDUCE - Density feature. Establishes time in which the allowed gap is reduced from passage time to minimum gap, after the time before reduction has expired.
8. MINIMUM GAP - Density feature. Establishes minimum value to which allowed gap between actuations on phase with green can be reduced upon expiration of time to reduce.
9. MAXIMUM GREEN - Establishes the maximum limit to which the green interval can be extended on a phase in the present of a serviceable demand on a conflicting phase.
10. YELLOW - Establishes the length of yellow interval following the green interval.
11. RED - Establishes the length of red interval following the yellow interval.
12. MEMORY MODES - Establishes whether the controller will remember (lock) or drop (non-lock) vehicle actuation.
13. RECALL MODES - Establishes whether the controller automatically returns to and provides right-of-way (green) on the selected phase once each traffic signal cycle, without the need for vehicle demand for service. There is pedestrian, minimum vehicle and maximum vehicle recall modes.

4.3 Local Free By TOD

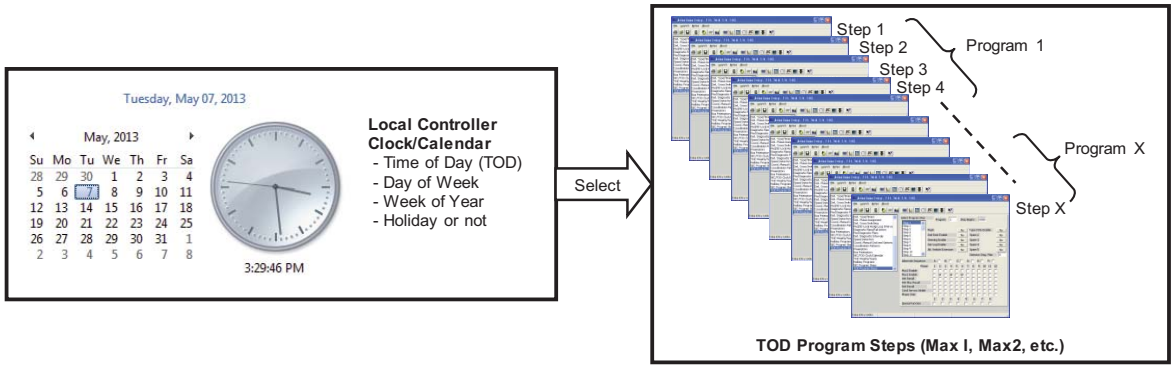
The above section lists some of the settings required for a local intersection controller. Some of these values can vary based on a time of day (TOD), day of week, week of year and special holiday program. Some of the parameters that can be changed include:

- ✓ Maximum time setting (Max I, Max II, Max III)
- ✓ Dynamic Max
- ✓ Phase omit
- ✓ Conditional service inhibit
- ✓ Flash
- ✓ Red Rest
- ✓ Alternate vehicle extension
- ✓ Alternate sequence
- ✓ Vehicle recall
- ✓ Vehicle max recall
- ✓ Pedestrian recall

Flashing Yellow Arrow operation (permitted, protected, or protected/permitted) can also be run on a TOD basis. For details, refer to page 4-26.

The image below illustrates that the local controller will use the clock and day information to choose the appropriate program and step.

Exhibit 4-1 Local Controller TOD Program Step



This above image does not address intersections running in a coordinated system. The intent is for an intersection running in free mode operation. Coordinated systems will be discussed in Chapter 4.

4.4 Local Intersection Start-up Process

Start-up of a local intersection is the sequence of operation following a dark or flash condition.

Typical MnDOT operation once the intersection is powered up;

- ✓ Flash All Red for 10 seconds
- ✓ All Red for 6 seconds
- ✓ then begin service on Phases 2 & 6 green
- ✓ Normal sequence follows.

Below is information from the 2012 MN MUTCD, section 4D.31.

4D.31 Flashing Operation - Transition Out of Flashing Mode

STANDARD:

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

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

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

GUIDANCE:

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

When changing from the yellow-red flashing mode to steady (stop-and-go) mode, if there is no common major-street green interval, the provision of a steady red clearance interval for the other approaches before changing from a flashing yellow or a flashing red signal indication to a green signal indication on the major approach should be considered.

STANDARD:

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

OPTION:

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

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.

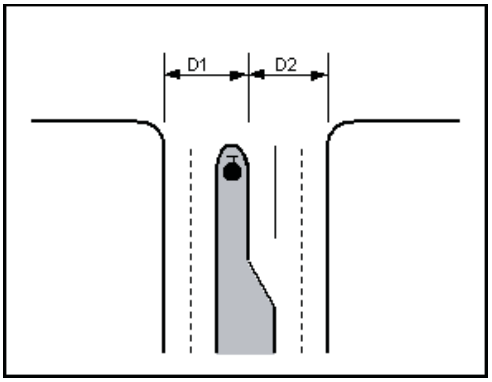
WALK = D1/R

flashing DON'T WALK = (D2/R)

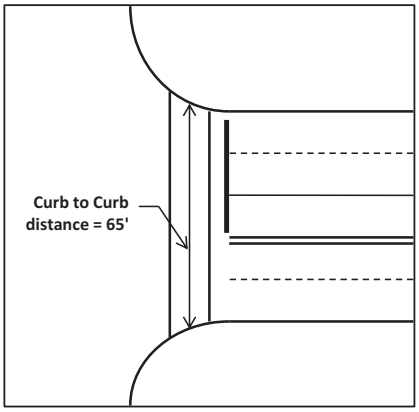
(this time may be less than the WALK time and the time may be reduced by the yellow time if it is necessary to minimize the pedestrian timing considering other factors)

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 (2012 MN MUTCD)

The following information is from the 2012 MN MUTCD. The latest information can be found by visiting the OTST website, www.dot.state.mn.us/trafficeng/publ/mutcd/index.html.

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 2.1 m (7 ft) nor more than 3 m (10 ft) 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.

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.

OPTION:

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 3.5ft per second, to at least the far side of the traveled way or to a median of sufficient width for pedestrians to wait.

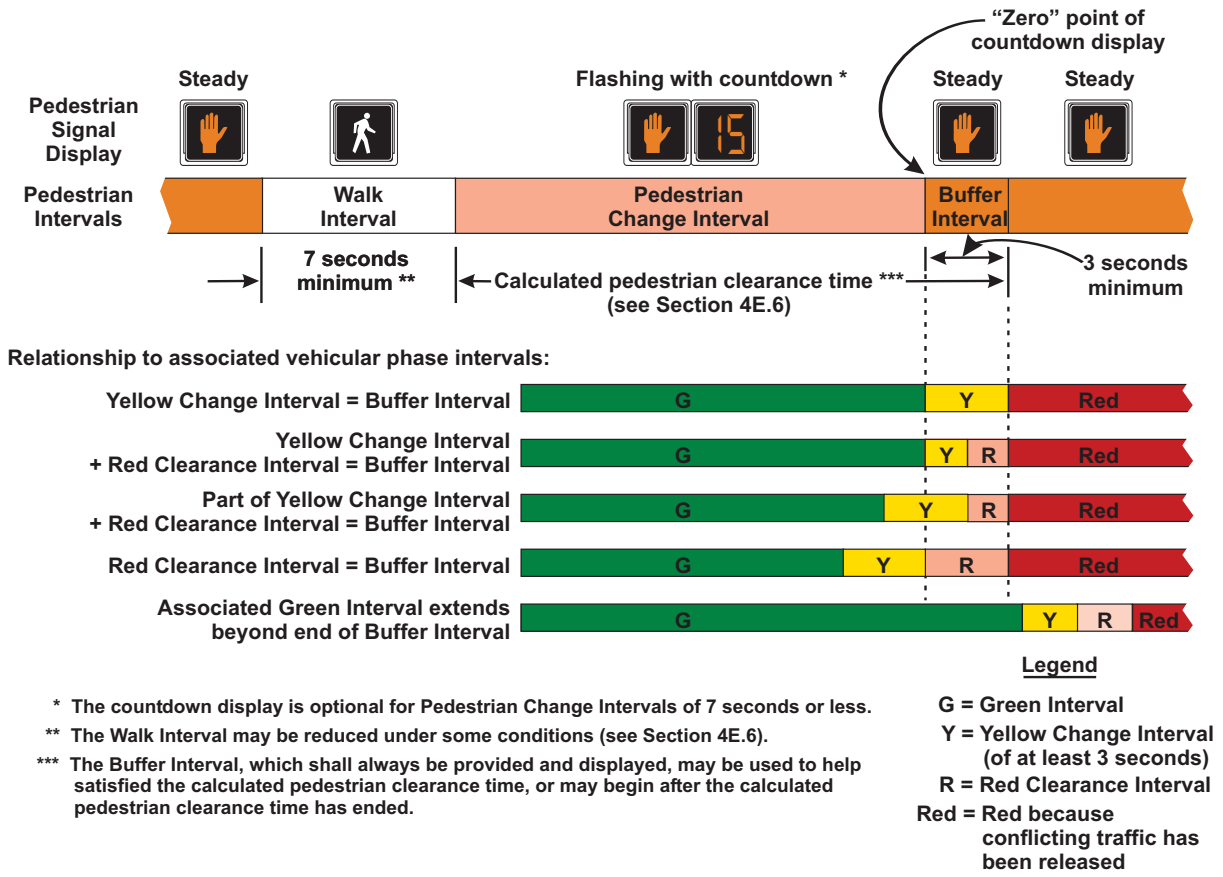
OPTION:

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 ft per second, or pedestrians who use wheelchairs, routinely use the crosswalk, a walking speed of less than 3.5 ft per second



* The countdown display is optional for Pedestrian Change Intervals of 7 seconds or less.

** The Walk Interval may be reduced under some conditions (see Section 4E.6).

*** The Buffer Interval, which shall always be provided and displayed, may be used to help satisfied the calculated pedestrian clearance time, or may begin after the calculated pedestrian clearance time has ended.

Figure 4E-2. Pedestrian Intervals

should be considered in determining the pedestrian clearance time.

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.

Operational requirements -
Compliance Date: December 22, 2006
Hardware -
Compliance Date: December 22, 2013

4E.8 Pedestrian Detectors

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

4.6 Initial Timing

Minimum Initial

The minimum initial time is the minimum assured green that is displayed. It is established to allow vehicles stopped between the detector on the approach and the stop line to get started and move into the intersection. Therefore, timing of this interval depends on the location of the detector and the number of vehicles that can be stored between the detector and the stop line. Consideration must be given to pedestrian timing, density operations, controller type and detection design when determining this setting. When there are no pedestrian provisions (indications or pushbuttons), the minimum assured green must be equal to the minimum pedestrian timing (walk + pedestrian clearance).

Non-density operation. In non-density operation the minimum initial green must be long enough to guarantee that vehicles stored between the detector and the stop line will clear the intersection before the clearance intervals terminate the movement. If stop line extending detection is used, the minimum initial green time should be set as for a density operation.

Density operation. In density operation the minimum initial green should be set low to clear a minimum of vehicles expected during light volume. Density operation has another timed interval that adds initial time per vehicle arriving on red for that approach. The initial green should not be set to low as to display an unexpected short green.

Minimum Initial (Density operation)

Major approach	=	15 seconds
		20 seconds (45 mph or above)
Minor approach	=	7-10 seconds (consider the lower values when split phasing is used)
Protected Left turn	=	7 seconds
Protected/Permissive	=	5 seconds

(Non-density operation)

Minimum initial green = 3 + 2n

n = Number of vehicles that can be stored between the stop line and the far detector in one lane. This is determined by dividing the distance between the stop line and the detector by 25. 25 is the average vehicle length plus headway in feet.

4.7 Density Features

Added Initial

Added initial is sometimes referred to as variable initial. This feature increases the minimum assured green time (minimum initial) so it will be long enough to serve the actual number of vehicles waiting for the green between the stop line and the detector.

This interval is generally used on phases for higher speed approaches where the detectors are placed quite a distance from the stop line (resulting in unacceptably long minimum initial requirements). This feature allows the minimum initial to be set low for light volumes. Vehicles crossing the detector when the phase is red will add time to the minimum assured green, so that when the phase is served, the minimum assured green will be long enough to serve the actual number of vehicles waiting for the green.

Consideration should be given to the number of lanes and detectors, distance from the stop line to detector, number of right turn vehicles, approach grades, type of controller, etc.

Field observation is very important in determining this setting.

Most controllers used in MnDOT utilize the function settings of "Actuations Before Added Initial" and "Added Initial Per Actuation" to determine Added Initial.

This is calculated by the following:

D/25 x 2.1 + 3

Example: If detector is 400' from stop line, then

400/25 x 2.1 + 3 = 16 x 2.1 + 3 = 36.6 seconds

Actuations Before Added Initial (Traconex) is the number of vehicles which can be adequately served by the time set on the minimum initial

	One Lane	Two Lanes
15 second Minimum Initial	6	10
20 second Minimum Initial	8	14

This is determined by: (minimum initial - 3) / 2

Two lane is 1.75 of one lane.

Added Initial Per Actuation is the amount of time that each vehicle crossing the detector on red should add to the minimum assured green.

One Lane: 2.0 seconds per actuation

Two Lane: 1.5 seconds per actuation

Passage Time

This function setting is the same for non-density and density operation. This setting should be the number of seconds required for a vehicle moving at the approach speed to travel from the detector to the stop line. The passage time serves two purposes. It is the passage time from the detector to the stop line and the allowable time gap between actuations that will cause the green to remain on that approach. As long as vehicle detections come at shorter intervals than the passage time (allowable gap), the green will be retained on that phase. In the density operation, the allowable gap is reduce by another timing feature.

If the passage interval is too short, quick stops may result as well as terminating the green before the vehicular movement has been adequately served. If the passage interval is set too long, excessive delays will result as well as safety problems due to improperly timed last vehicle intervals.

Passage Time = $^{D}/_{1.47S}$ (general range is 2.0 - 8.0 seconds)

D = Distance from the stop line to back detector, if single point detection. Distance (greatest distance) between stop line and/or detectors, if multiple detection.

S = Posted speed limit in mph

HANDOUT

GAP REDUCTION - Density Feature

This feature reduces the passage time and as a result reduces the allowable time gap between actuations that will cause the green to remain on that approach.

When a phase is green the time between vehicles to terminate that phase starts out at amount of time set for the passage time (i.e., successive actuations must be closer together than the passage time to extend the green). After the phase has been green for some time, it becomes desirable to terminate the phase on smaller distances between vehicles. This is done to reduce the probability of the phase being terminated at the maximum time. **When a phase terminates at maximum time there is no dilemma zone protection**. This feature is generally used on phases for higher speed approaches where the detectors are placed quite a distance from the stop line (resulting in long passage timing).

Most controller used by MnDOT utilize the time setting of "Time Before Reduction", "Time To Reduce" and "Minimum Gap"

Time Before Reduction establishes the time before the passage time (allowable gap) begins to reduce.

Time To Reduce establishes the time in which the allowable gap is reduced from the passage time to the minimum gap, after the time before reduction has expired.

Minimum Gap establishes the minimum value to which the allowable gap between actuations can be reduced to upon expiration of the time to reduce.

Generally the minimum gap should not be set lower than 2 seconds. This is the average headway between vehicles and is approximately the time it takes a vehicle to travel from the detector through the dilemma zone. The amount of time into the green to reduce to the minimum gap should be set at about 2/3 of the maximum time. The allowable gap will gradually reduce in that time frame. Therefore, the last 1/3 of the maximum green would be extended only by tightly spaced vehicles.

Time Before Reduction

This should be set for 1/3 maximum time.

Time To Reduce

This should be set for 1/3 maximum time.

Minimum Gap

Minimum Gap = Passage time minus the time in seconds between the stop line and the end of the dilemma zone (MnDOT uses 2.0)

Note: Gap reduction is normally not used when stop bar detectors exist. Gap reduction with stop bar detectors require special detector functions and timings.

During moderate flow conditions a well-timed actuated signal should terminate due to gap-out rather than due to max-out. The goal of good green timing should be to terminate the green indication on gap out and to max out only under heavy traffic conditions (tightly spaced vehicles).

Detector Extend

The sections above discuss per phase controller settings. That is, the setting in the controller applies to the given movement/phase. There are also additional functions that allow this to be extended with the detectors. Some users will use a "per phase" extension and an additional extension "by detector".

Refer to the following image. In this example, the passage time is set to 2 seconds. This 2 seconds may be adequate to get a vehicle from Detector 1 through or to the intersection. However, the 2 seconds of time

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
- ✓ Real-time split monitoring and time space reporting
- ✓ Incident detection
- ✓ Light rail control systems
- ✓ Transit priority systems
- ✓ 1.5 generation timing plan development using Synchro or PASSER
- ✓ 2.0 Generation control (Traffic Responsive and Traffic Adaptive)
- ✓ Integrated video detection
- ✓ Real time preemption log retrieval

Time-Space Diagrams

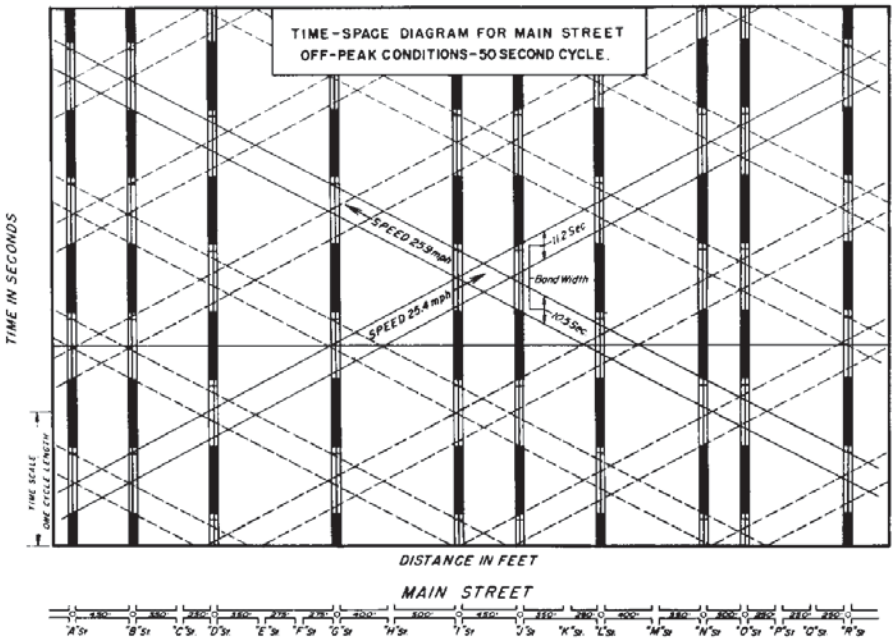
These are prepared to determine the offsets on individual intersections.

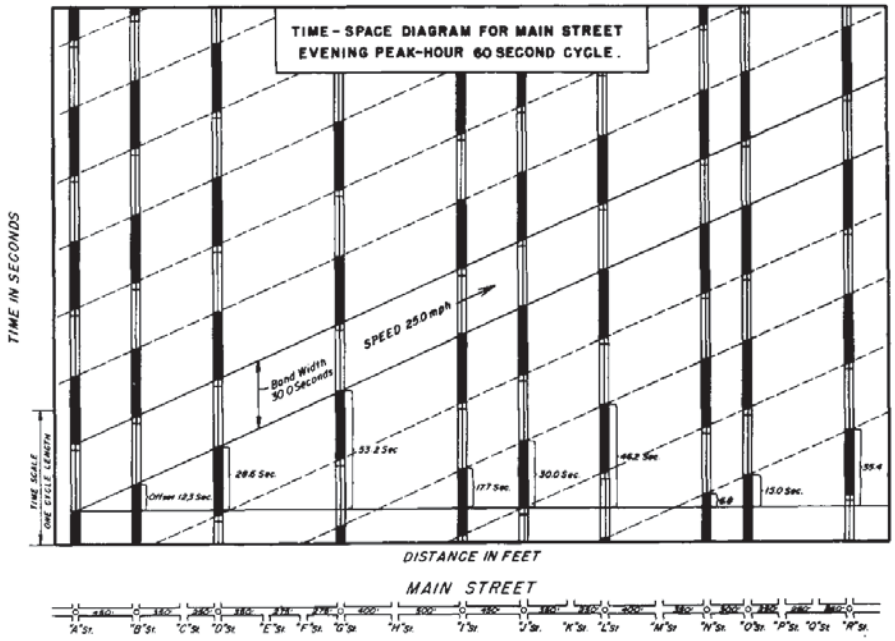
A time-space diagram is a chart on which distance is plotted against time. The location of each signalized intersection is plotted along one axis. At each such point the signal color sequence and split are plotted in such a manner that through bands are available for each direction of traffic flow. The slope of the through band (distance divided by time) is the speed of progression, and width indicates the time available for a platoon traveling through systems.

For two-way streets, the diagram is usually prepared to give equal consideration to each direction of travel. Where appropriate types of program controllers are available, separate peak-hour diagrams are prepared for streets carrying heavy directional peak volumes; these will favor travel in the peak direction. The cycle length may be changed (for the entire system) and the offsets are changed through the use of time clocks in the master controller. Sample time-space diagrams for off-peak and evening peak periods are shown in the figures below.

When a coordinated system is established for a certain speed during all periods of the day, supplemental signs may be erected which inform the driver of that speed.

Exhibit 5-4 Sample Time Space Diagrams





Complex Timing Systems. Development of timing parameters and programs for the more sophisticated signal systems is very specialized and depends greatly on the specific system components and configuration. Timing techniques, methodology, and philosophy are receiving considerable attention. Extensive research in these areas is continuing. Computer programs have been developed for timing networks such as Synchro.

Control Philosophies for Computerized Traffic Signal Systems

The progress of the state of the art in traffic signal control systems is a function of the technological development of computer applications and control philosophies. Generally, control philosophies may be categorized as follows:

First Generation

These programs are basically of the table look-up type. A number of essentially fixed timing patterns have been precomputed and stored. Control plans are selected based on time of day or on sensing certain demand parameters at strategically located detectors. As threshold positions are reached, alternative predeveloped and stored control plans are implemented. This procedure is used in most of the presently operational digital computer controlled systems.

Second Generation

This type of control program is still based on a background cycle, but provides for on-line, real time computation of control plans and strategies. It utilizes a prediction model to predict near-term (e.g., 15-minute) changes in traffic demand. Current conditions and these predictions are then used in an on-line optimization program to compute splits and offsets.

1.5 Generation Control

1.5 GC utilizes on-line data collection and predetermined algorithms to generate input data to the TRANSYT-7F timing program. A new timing plan is computed and compared to the existing timing plan. Currently, the operator must decide whether the improvement is worth implementing on either a temporary or permanent basis.

Comparison

The FHWA sponsored extensive research in evaluating the first and second generations of control under the Urban Traffic Control System (UTCS) program. The abstract of the Executive Summary of the Evaluation Study states:

"The First Generation...was found to be operationally effective, was the least expensive to apply, and should be given primary consideration for implementation. Second Generation proved effective on arterials, was only slightly more costly to implement than [first generation], and should be given consideration for areas with substantial arterial development."

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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 Technical Memorandum No. 12-10-T-03.

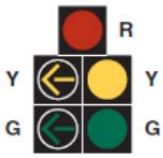
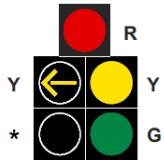
The figures are divided into four sections as follows:

- 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)."*

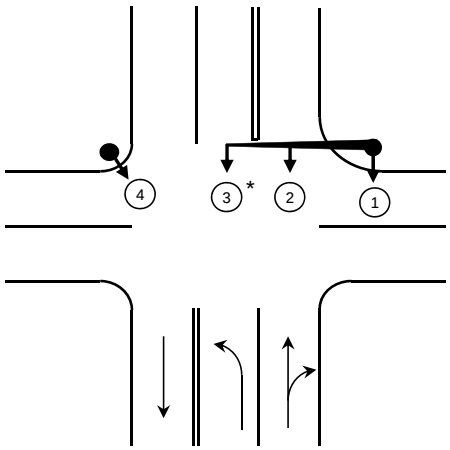
The following abbreviations are used in the figures in this chapter:

Abbreviation	Description	Arrangement
R-Y-G	Three-Section Red, Yellow, Green Ball	
R-Y-G-YLA-GLA	Five-Section Red, Yellow, Green Ball and Yellow, Green Left Turn Arrow	
RLA-YLA-GLA	Three-Section Red, Yellow Green Left Turn Arrow	
RLA-YLA-FYLA-GLA	Four-Section Red, Yellow, Green Left Turn Arrow and Flashing Yellow Left Turn Arrow	 * Shall not be displayed when operating in the protected only mode
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

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

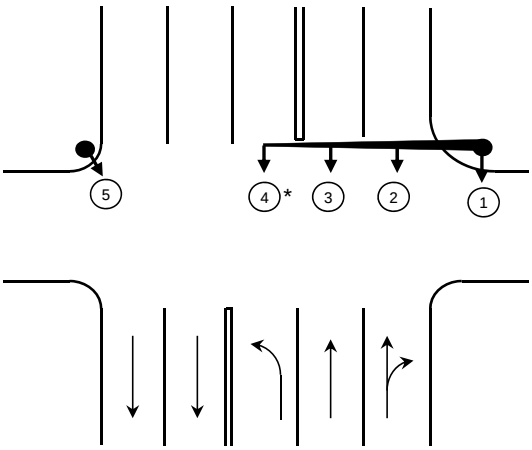


NOTE:
OVERHEAD SIGNAL FACES SHOULD BE LOCATED OVER THE CENTERS OF THE APPROACH LANES.

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

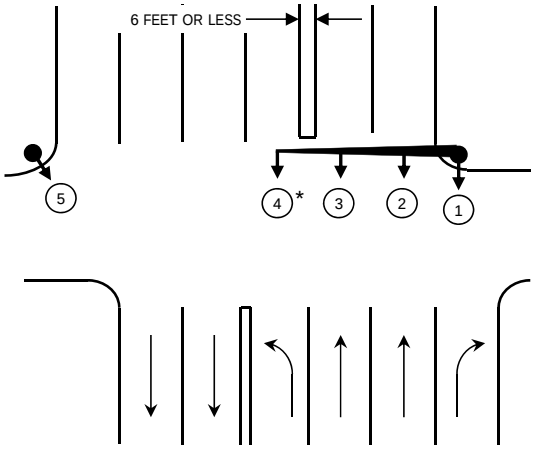


NOTE:
OVERHEAD SIGNAL FACES SHOULD BE LOCATED OVER THE CENTERS OF THE APPROACH LANES.

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



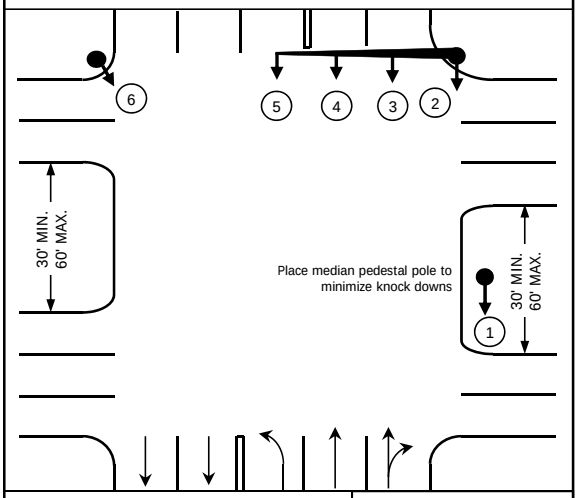
NOTE:
OVERHEAD SIGNAL FACES SHALL BE LOCATED OVER THE CENTERS OF THE APPROACH LANES.

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

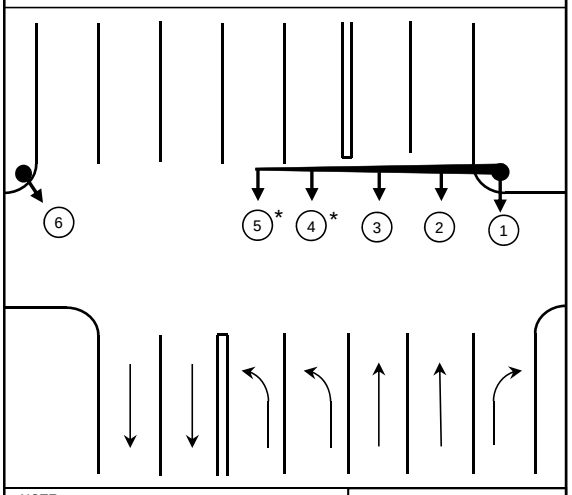
SIGNAL FACE NO. 2 IS OPTIONAL

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



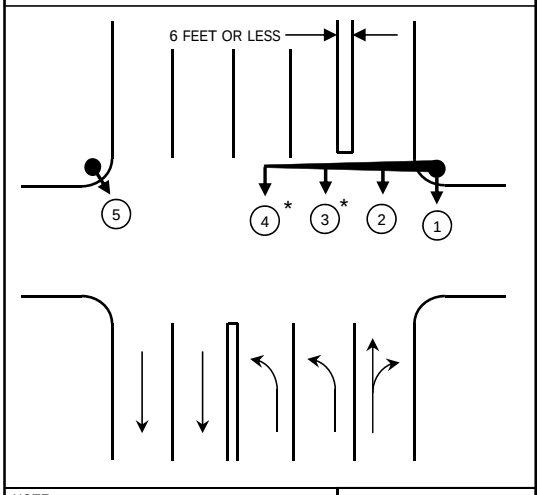
NOTE:
OVERHEAD SIGNAL FACES SHOULD BE LOCATED OVER THE CENTERS OF THE APPROACH LANES.

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



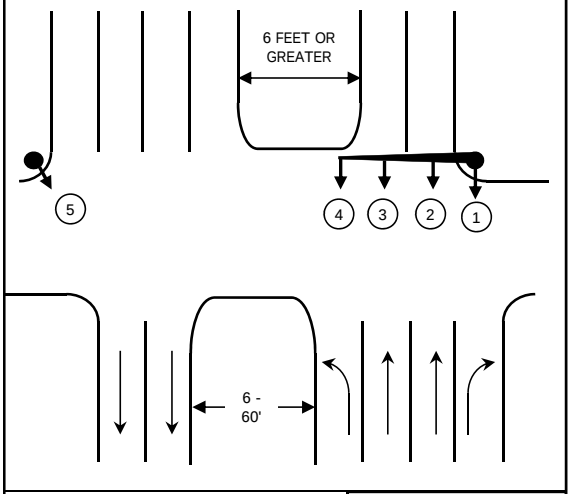
NOTE:
OVERHEAD SIGNAL FACES SHOULD BE LOCATED OVER THE CENTER OF THE APPROACH LANES.

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.

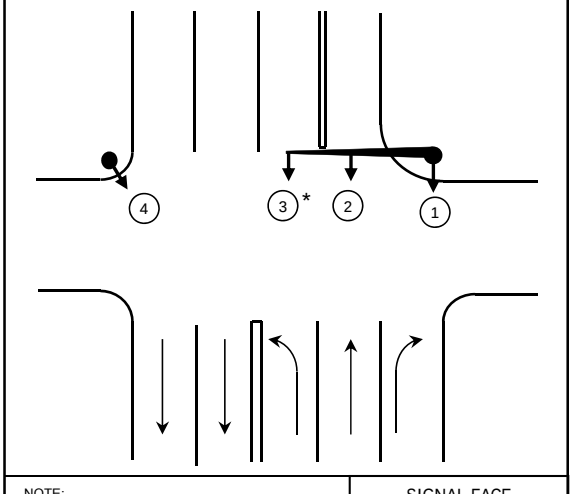
A PEDESTAL MOUNTED SIGNAL INDICATION MAY BE USED INPLACE OF OVERHEAD SIGNAL FACE NO. 4.

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

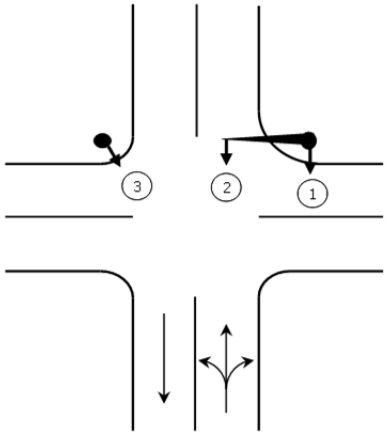
1	R-Y-G
2	R-Y-G
3	RLA-YLA-FYLA-GLA
4	RLA-YLA-FYLA-GLA

* 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.

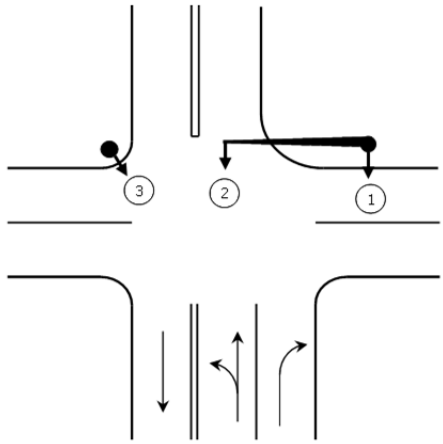
SIGNAL FACES 2 AND 3 ARE THE 5-SECTION BI-MODAL SIGNAL INDICATIONS.

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.

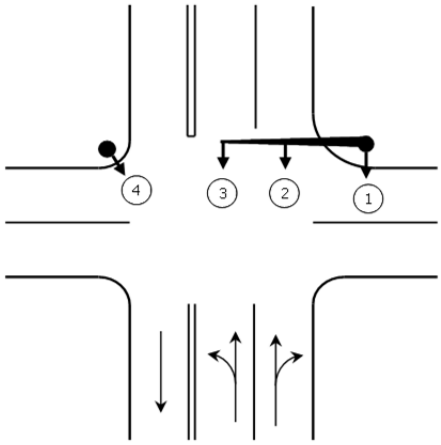
SIGNAL FACES 2 AND 3 ARE THE 5-SECTION BI-MODAL SIGNAL INDICATIONS.

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.

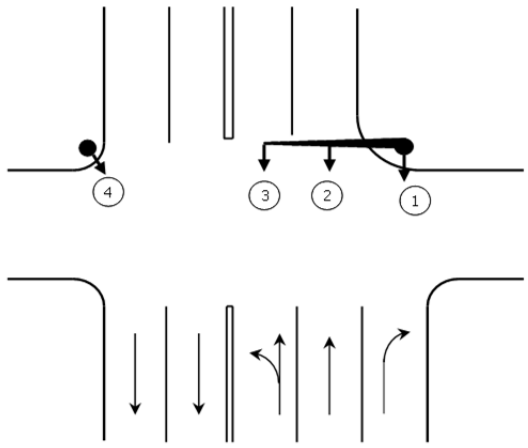
SIGNAL FACES 3 AND 4 ARE THE 5-SECTION BI-MODAL SIGNAL INDICATIONS.

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.

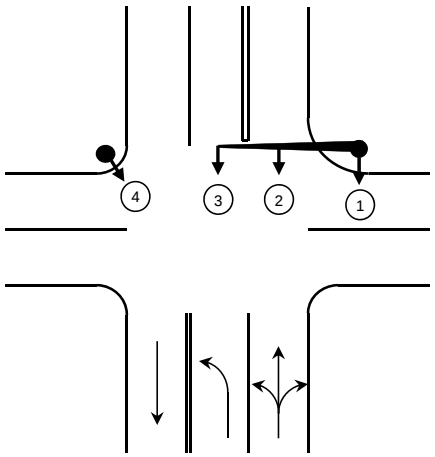
SIGNAL FACE INDICATIONS

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.

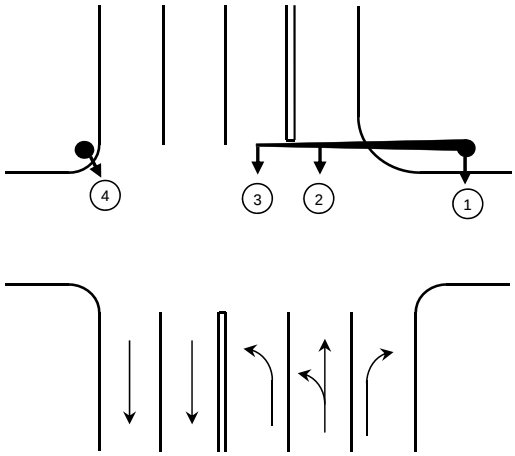
SIGNAL FACE 2 IS THE 5-SECTION BI-MODAL SIGNAL INDICATION.

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.

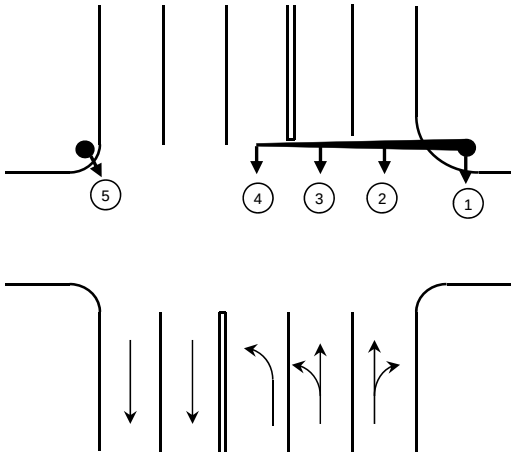
SIGNAL FACE 2 IS THE 5-SECTION BI-MODAL SIGNAL INDICATION.

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.

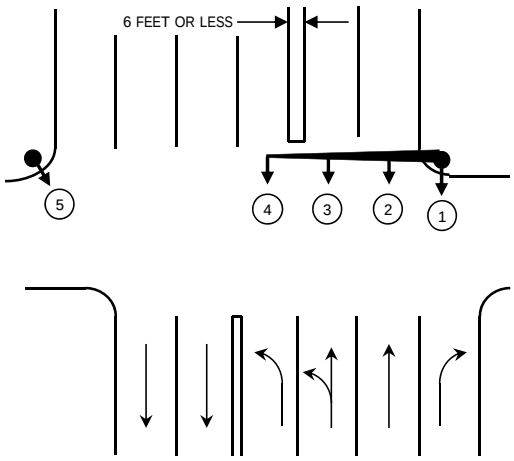
SIGNAL FACE 3 IS THE 5-SECTION BI-MODAL SIGNAL INDICATION.

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

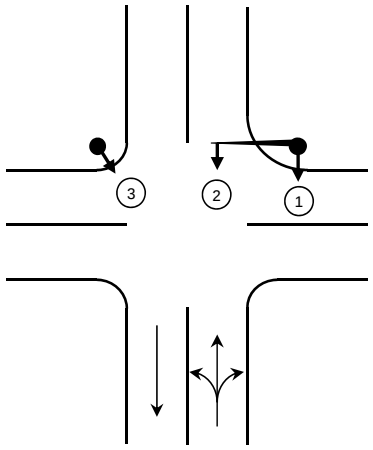
1. R-Y-G
2. R-Y-G
3. R-Y-G-YLA-FYLA-GLA
4. RLA-YLA-FYLA-GLA
5. RLA-YLA-FYLA-GLA

NOTE: FYA should not be used if opposing left turn vehicle paths overlap.

3.3 LOW SPEED (NON-FLASHING YELLOW ARROW) CHARTS

Figure 17

SINGLE LANE OF APPROACH
LOW SPEEDS

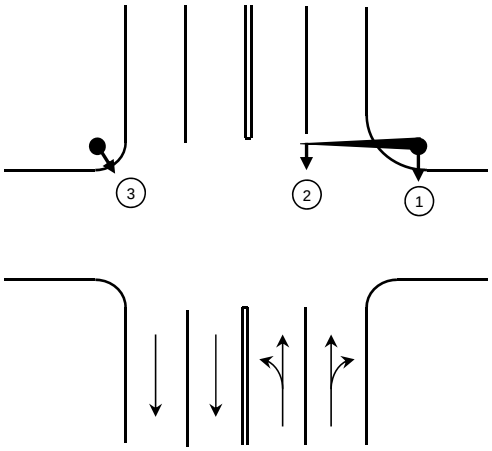


NOTE:
OVERHEAD SIGNAL FACE NO. 2 SHOULD BE LOCATED OVER THE CENTER OF THE THROUGH LANE.

SIGNAL FACE INDICATIONS	
1	R-Y-G
2	R-Y-G
3	R-Y-G

Figure 18

TWO LANES OF APROACH
LOW SPEEDS

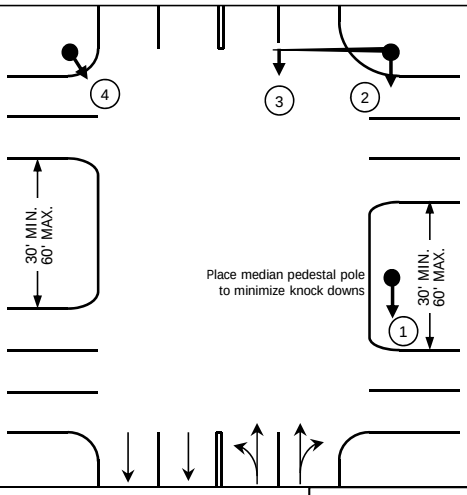


NOTE:
OVERHEAD SIGNAL FACE NO. 2 SHOULD BE LOCATED OVER THE LANE LINE.

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.

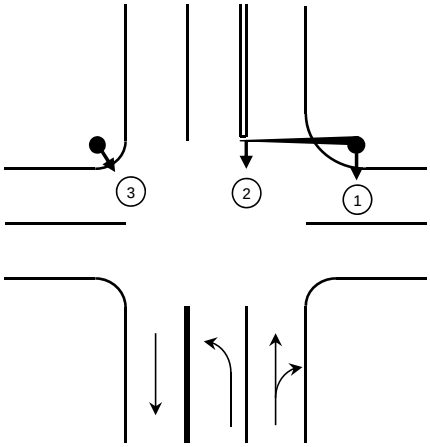
SIGNAL FACE NO. 1 SHOULD BE A PEDESTAL MOUNTED SIGNAL INDICATION

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

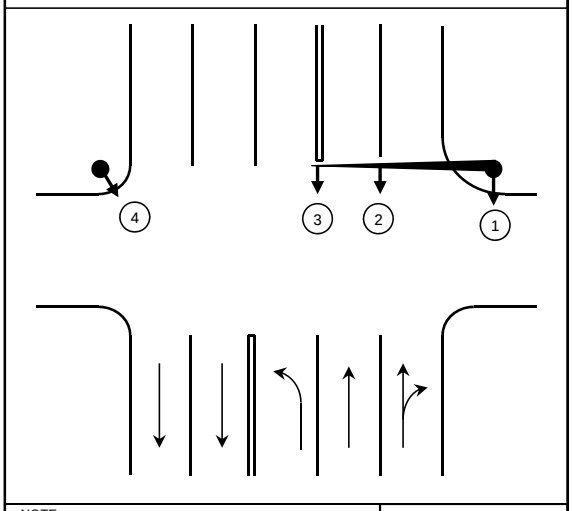


NOTE:
OVERHEAD SIGNAL SHOULD BE LOCATED OVER THE LANE LINE.

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.

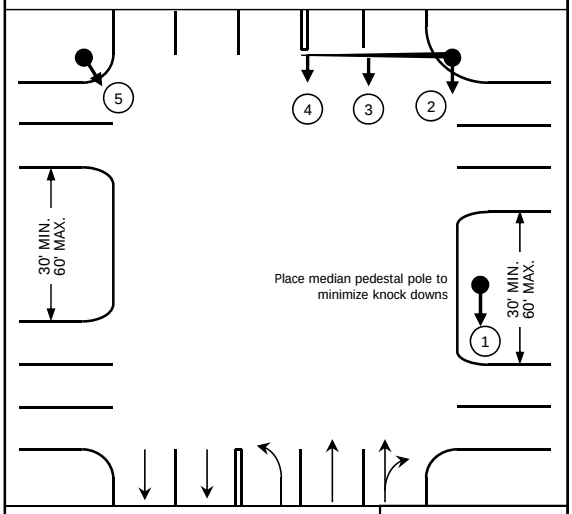
IF THREE OR MORE THRU LANES, ANOTHER SIGNAL FACE SHOULD BE PLACED OVER THE GIVEN LANE LINE.

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.

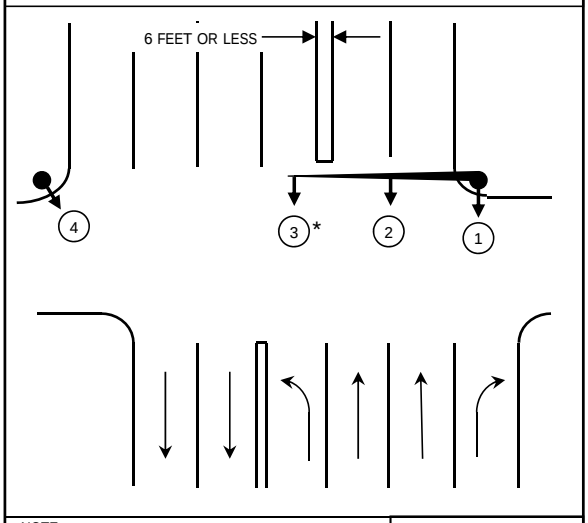
SIGNAL FACE INDICATIONS

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.

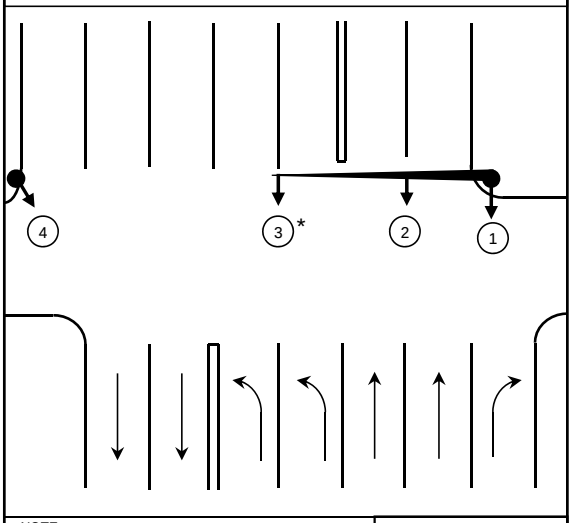
IF THREE OR MORE THRU LANES, ANOTHER SIGNAL FACE SHOULD BE PLACED OVER THE GIVEN LANE LINE.

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.

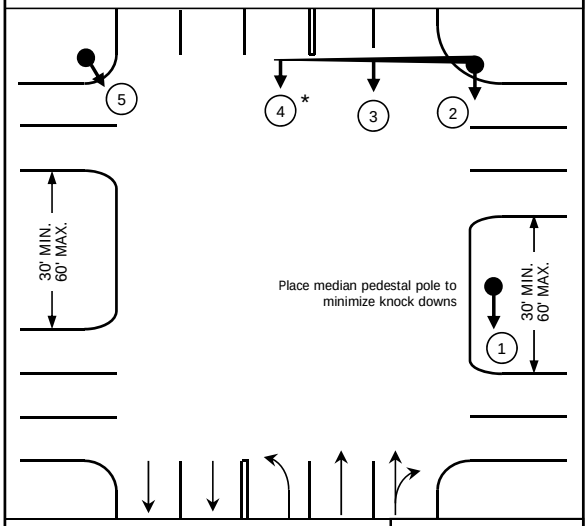
OVERHEAD SIGNAL FACE NO. 3 SHOULD BE LOCATED OVER THE LEFT TURN LANE LINES

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.

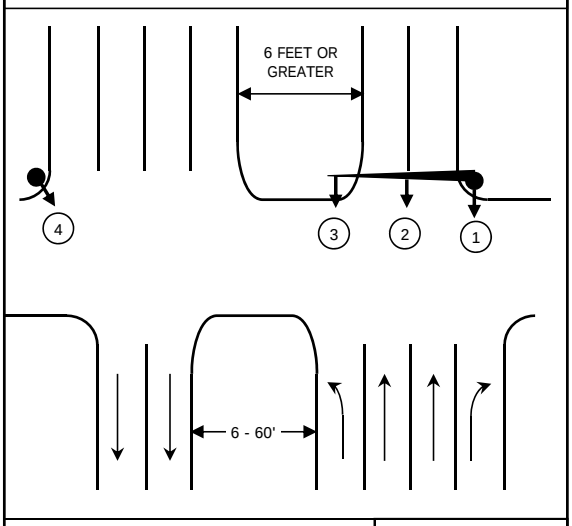
SIGNAL FACE NO. 2 IS OPTIONAL.

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.

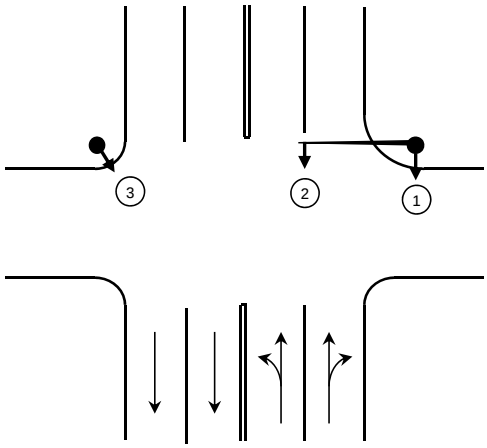
SIGNAL FACE INDICATIONS

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



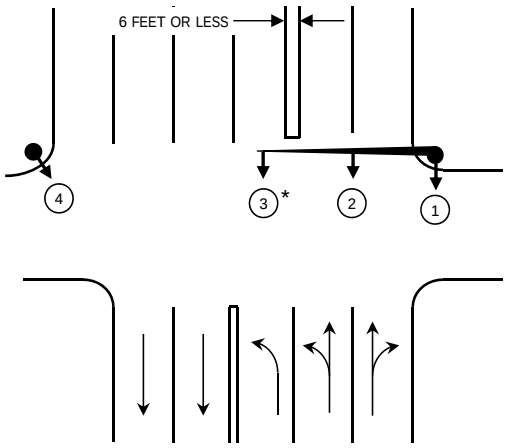
NOTE:
OVERHEAD SIGNAL FACE NO. 2 SHOULD BE LOCATED OVER THE LANE LINE.

SIGNAL FACE INDICATIONS

1. R-Y-G
2. R-Y-G-GLA
3. R-YLTA-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.

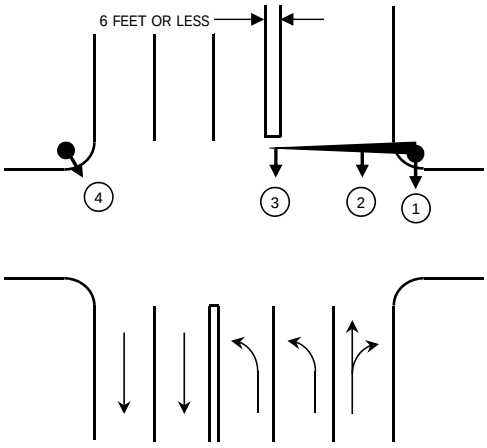
OVERHEAD SIGNAL FACE NO. 3 SHOULD BE LOCATED OVER THE CENTER OF THE LEFT TURN LANE.

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.

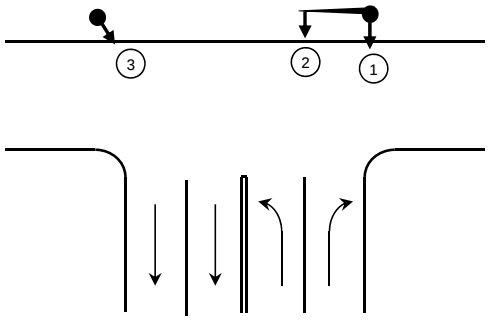
OVERHEAD SIGNAL FACE NO. 3 SHOULD BE LOCATED OVER THE LANE LINE BETWEEN THE LEFT TURN LANES.

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

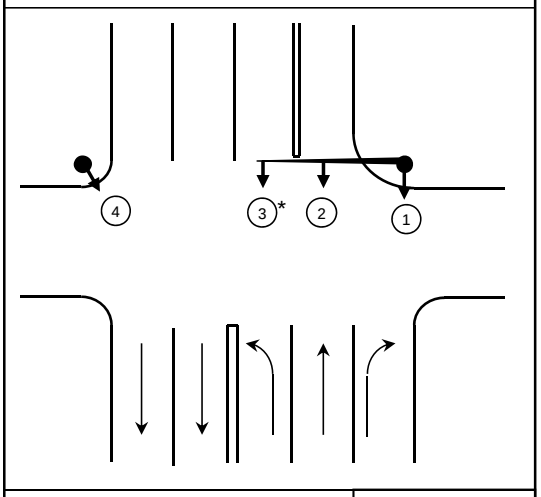
1. R-Y-G
2. R-Y-G
3. R-Y-G

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.

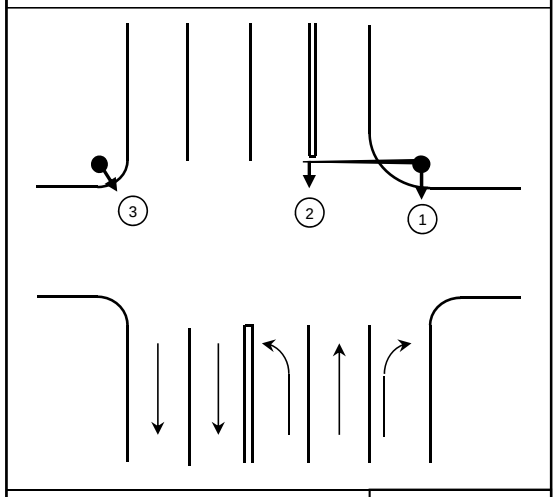
OVERHEAD SIGNAL FACE NO. 3 SHOULD BE LOCATED OVER THE CENTER OF THE LEFT TURN LANE.

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

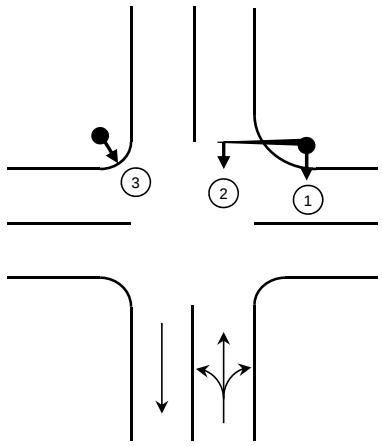
1. R-Y-G
2. R-Y-G-YLA-GLA
3. R-Y-G-YLA-GLA

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

3.4 HIGH SPEED (NON-FLASHING YELLOW ARROW) CHARTS

Figure 35

SINGLE LANE OF APPROACH
HIGH SPEEDS



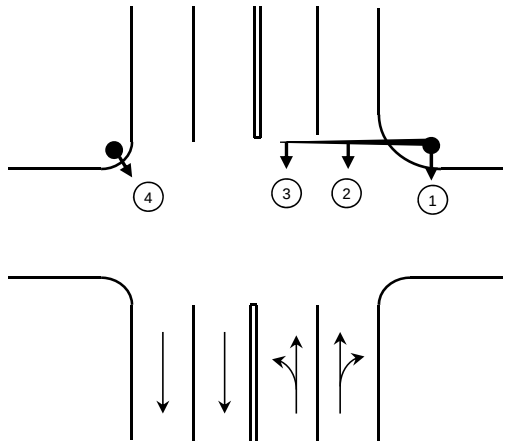
NOTE:
OVERHEAD SIGNAL FACE NO. 2 SHOULD BE LOCATED OVER THE CENTER OF THE THROUGH LANE.

SIGNAL FACE INDICATIONS

1 R-Y-G
2 R-Y-G
3 R-Y-G

Figure 36

TWO LANES OF APPROACH
HIGH SPEEDS



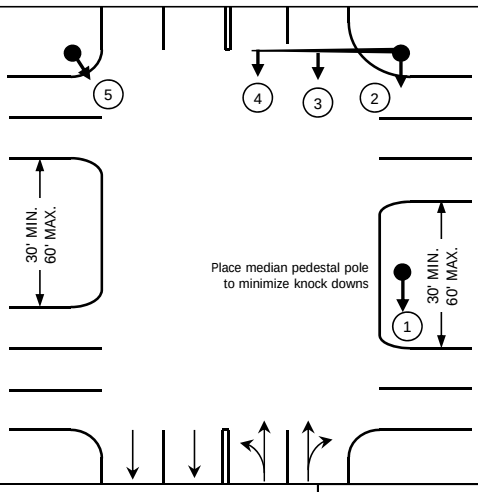
NOTE:
OVERHEAD SIGNAL FACE NO. 2 AND NO. 3 SHOULD BE LOCATED OVER THE CENTER OF THE APPROACH LANES.

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

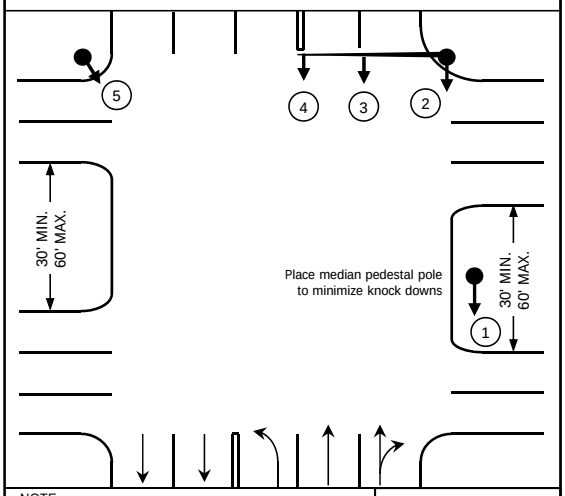
SIGNAL FACE NO. 2 IS OPTIONAL

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

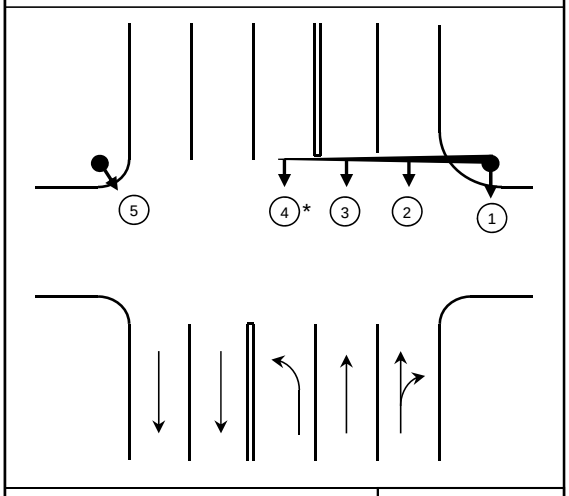
OVERHEAD SIGNAL FACE NO. 4 SHOULD BE LOCATED OVER THE LANE LINE (NOT CENTERED OVER LEFT LANE)

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



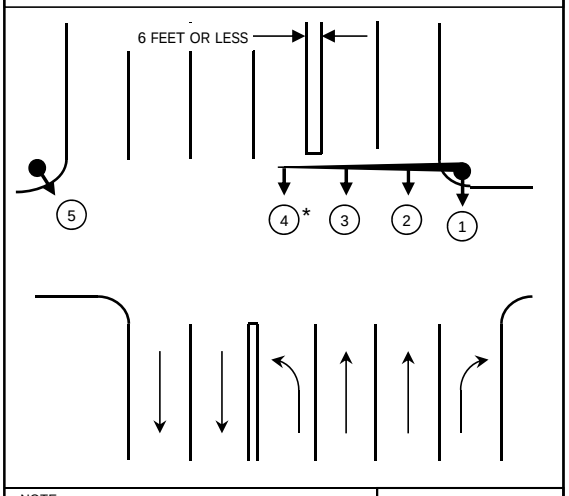
NOTE:
OVERHEAD SIGNAL FACES SHOULD BE LOCATED OVER THE CENTERS OF THE APPROACH LANES.

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.

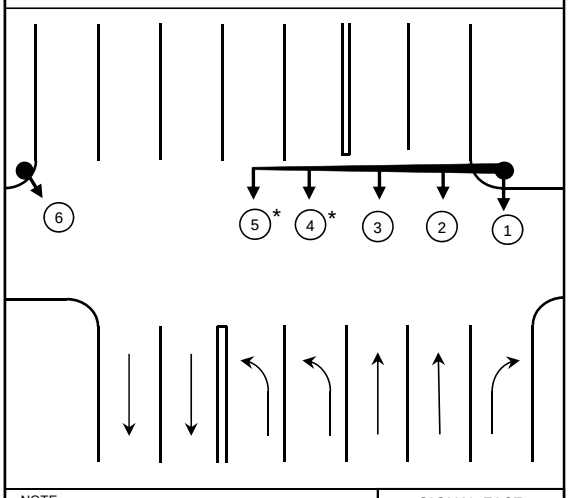
IF THREE OR MORE THRU LANES, ANOTHER SIGNAL FACE SHOULD BE PLACED OVER THE GIVEN LANE.

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



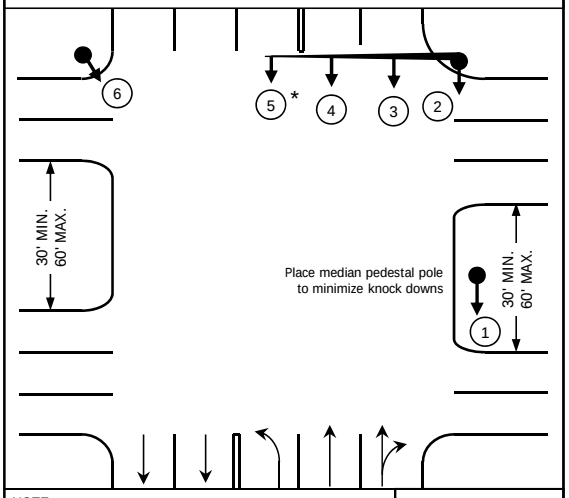
NOTE:
OVERHEAD SIGNAL FACES SHOULD BE LOCATED OVER THE CENTER OF THE APPROACH LANES.

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.

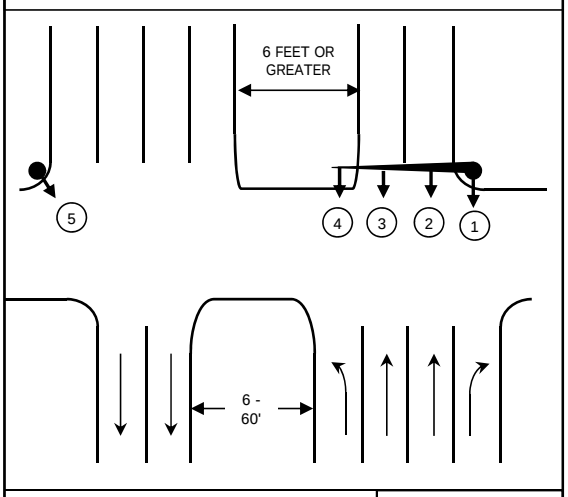
SIGNAL FACE

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.

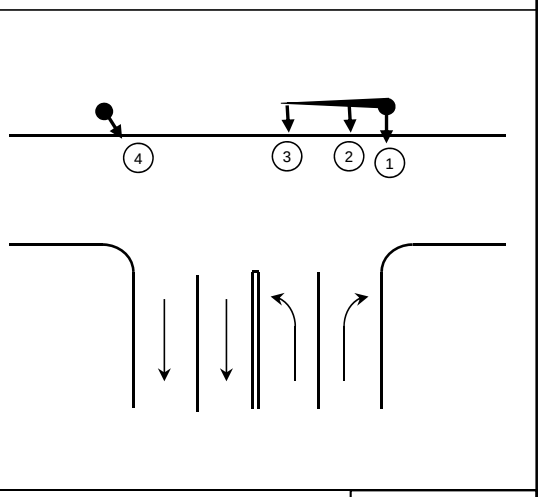
A PEDESTAL MOUNTED SIGNAL INDICATION MAY BE USED INPLACE OF OVERHEAD SIGNAL FACE NO. 4.

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

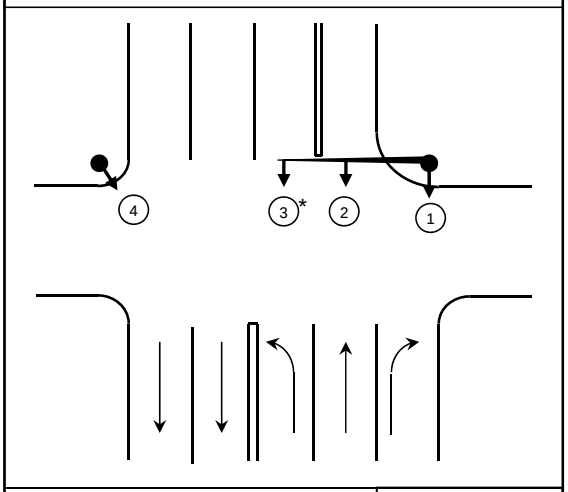
SIGNAL FACE INDICATIONS

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.

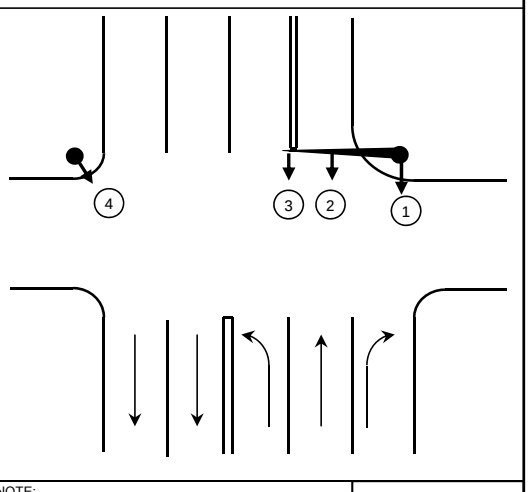
OVERHEAD SIGNAL FACE NO. 3 SHOULD BE LOCATED OVER THE CENTER OF THE LEFT TURN LANE.

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.

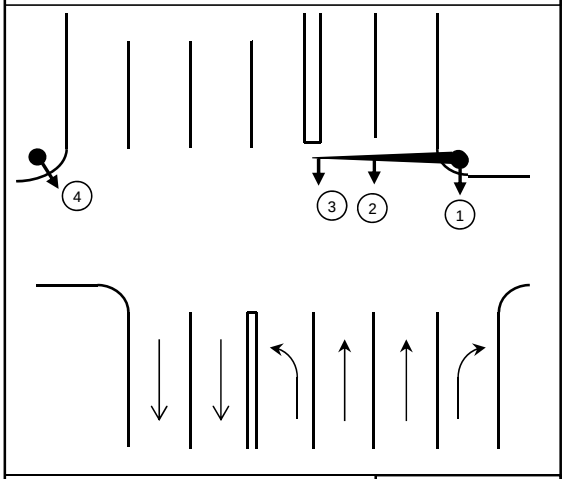
SIGNAL FACE INDICATIONS

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.

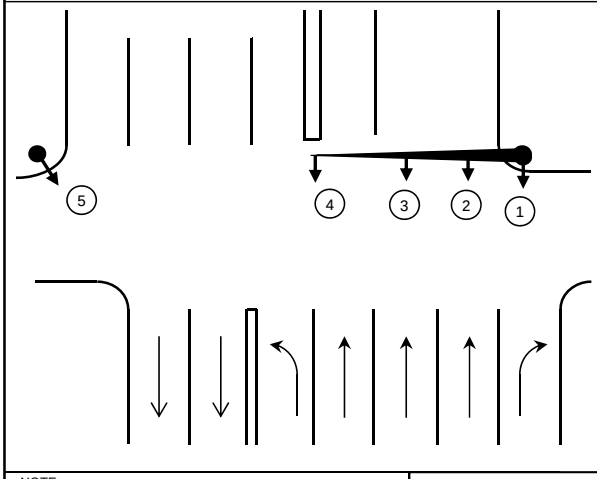
OVERHEAD SIGNAL FACE 3 SHOULD BE LOCATED OVER THE LANE LINE (NOT CENTERED OVER LEFT LANE).

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

3.5 SIGNAL HEAD LOCATIONS

The information following this sheet is a handout taken from the Minnesota Manual on Uniform Traffic Control Devices (MN MUTCD) pages 4D-8 to 4D-39.

The most current version of the MN MUTCD can be found at:

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

Note: It is recommended that you review all original reference material.

SUPPORT:

Research has resulted in signal optical units that are not lenses, such as, but not limited to, light-emitting diode (LED) traffic signal modules. Some units are practical for all signal indications, and some are practical for specific types such as visibility-limited signal indications.

GUIDANCE:

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

4D.7 Size of Vehicular Signal Indications

STANDARD:

There shall be two nominal diameter sizes for vehicular signal indications: 8 inches and 12 inches.

Except as provided in the following Option, 12-inch signal indications shall be used for all signal sections in all new signal faces.

OPTION:

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

A. The green or flashing yellow signal indications in an emergency-vehicle traffic control signal (see Section 4G.2);
B. The circular indications in signal faces controlling the approach to the downstream location where two adjacent signalized locations are close to each other and it is not practical because of factors such as high approach speeds, horizontal or vertical curves, or other geometric factors to install visibility-limited signal faces for the downstream approach;
C. The circular indications in a signal face that is located less than 120 feet from the stop line on a roadway with a posted or statutory speed limit of 30 mph or less;
D. The circular indications in a supplemental near-side signal face:
E. The circular indications in a supplemental signal face installed for the sole purpose of controlling pedestrian movements (see Section 4D.3) rather than vehicular movements; and
F. The circular indications in a signal face installed for the sole purpose of controlling a bikeway or a bicycle movement.

Existing 8-inch circular signal indications that are not included in Items A through F in the previous Option may be retained for the remainder of their useful service life.

4D.8 Positions of Signal Indications Within a Signal Face - General

SUPPORT:

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

STANDARD:

Unless otherwise provided in this Manual for a particular applications, each signal face at a signalized location shall have three, four, or five signal sections. Unless otherwise provided in this Manual for a particular application, if vertical signal face includes a cluster (see Section 4D.9), the signal face shall have at least three vertical positions.

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

The signal sections in a signal face shall be arranged in a vertical or horizontal straight line, except as otherwise provided in Section 4D.9.

The arrangement of adjacent signal sections in a signal face shall follow the relative positions listed in Sections 4D.9 or 4D.10, as applicable.

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

If a U-turn arrow signal section is used in a signal face for a U-turn to the left, its position in the signal face shall be the same as stated in Sections 4D.9 and 4D.10 for a left-turn arrow signal section of the same color. If a U-turn arrow signal section is used in a signal face for a U-turn to the right, its position in the signal face shall be the same as stated in Sections 4D.9 and 4D.10 for a right-turn arrow signal section of the same color.

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

OPTION:

Within a signal face, two identical CIRCULAR RED or RED ARROW signal indications may be displayed immediately horizontally adjacent to each other in a vertical

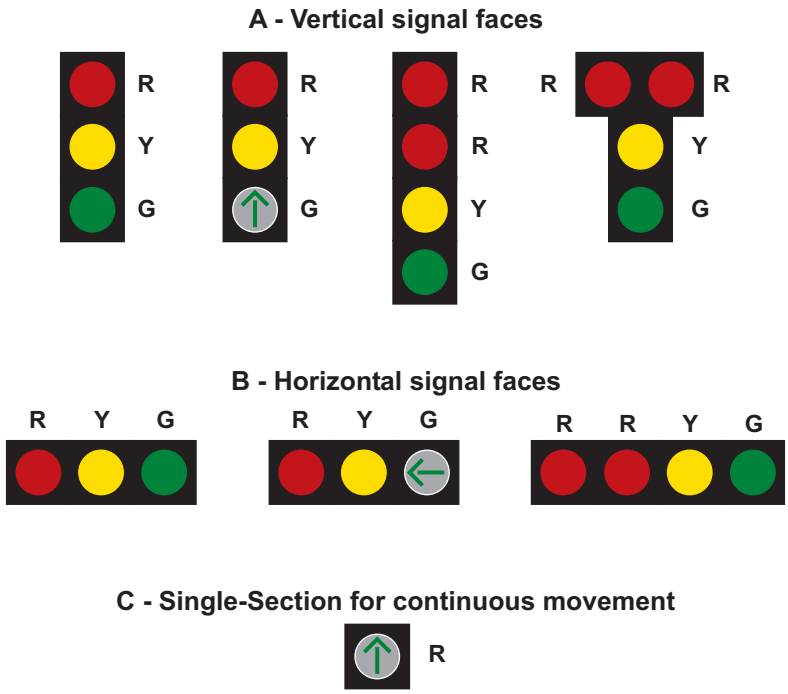


Figure 4D-2. Typical Arrangements of Signal Sections in Signal Faces That Do Not Control Turning Movements

or horizontal signal face (see Figure 4D-2) for emphasis.

Horizontally arranged and vertically arranged signal faces may be used on the same approach provided they are separated to meet the lateral separation spacing required in Section 4D.13.

SUPPORT:

Figure 4D-2 illustrates some of the typical arrangements of signal sections in signal faces that do not control separate turning movements. Figures 4D-6 through 4D-12 illustrate the typical arrangements of signal sections in left-turn signal faces. Figures 4D-13 through 4D-19 illustrate the typical arrangements of signal sections in right-turn signal faces.

4D.9 Positions of Signal Indications Within a Vertical Signal Face

STANDARD:

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

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

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

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

If a dual-arrow signal section (capable of alternating between the display of a GREEN ARROW and a YELLOW ARROW signal indication) is used, in a vertically-arranged signal face, the dual-arrow signal section shall occupy the same position relative to the other sections as the signal section that displays the GREEN ARROW signal indication in a vertically arranged signal face would occupy.

OPTION:

In a vertically arranged signal face, signal sections that display signal indications of the same color may be arranged horizontally adjacent to each other at right angles to the basic straight line arrangement to form a clustered signal face (see Figures 4D-2, 4D-8, 4D-9, 4D-11, 4D-15, 4D-16, 4D-18, and 4D-20).

STANDARD:

Such clusters shall be limited to the following:

A: Two identical signal sections,
B: Two or three different signal sections that display signal indications of the same color, or
C: For only the specific case described in Section 4D.25 (see Drawing B of Figure 4D-20), two signal sections, one of which displays a GREEN ARROW signal indication and the other of which displays a flashing YELLOW ARROW signal indication.

The signal section that displays a flashing yellow signal indication during steady mode operation:

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

SUPPORT:

Sections 4F.2 and 4G.4 contain exceptions to the provisions of this Section that are applicable to hybrid beacons.

4D.10 Positions of Signal Indications Within a Horizontal Signal Face

STANDARD:

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

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

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

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

If a dual-arrow signal section (capable of alternating between the display of a GREEN ARROW and a YELLOW ARROW signal indication) is used in a horizontally-arranged signal face, the signal section that displays the dual left-turn arrow signal indication shall be located immediately to the right of the signal section that displays the CIRCULAR YELLOW signal indication, the signal section that displays straight-through GREEN ARROW signal indication shall be located immediately to the right of the signal section that displays the CIRCULAR GREEN signal indication, and the signal section that displays the dual right-turn arrow signal indication shall be located to the right of all other signal sections.

The signal section that displays a flashing yellow signal indication during steady mode operation:

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

4D.11 Number of Signal Faces on an Approach

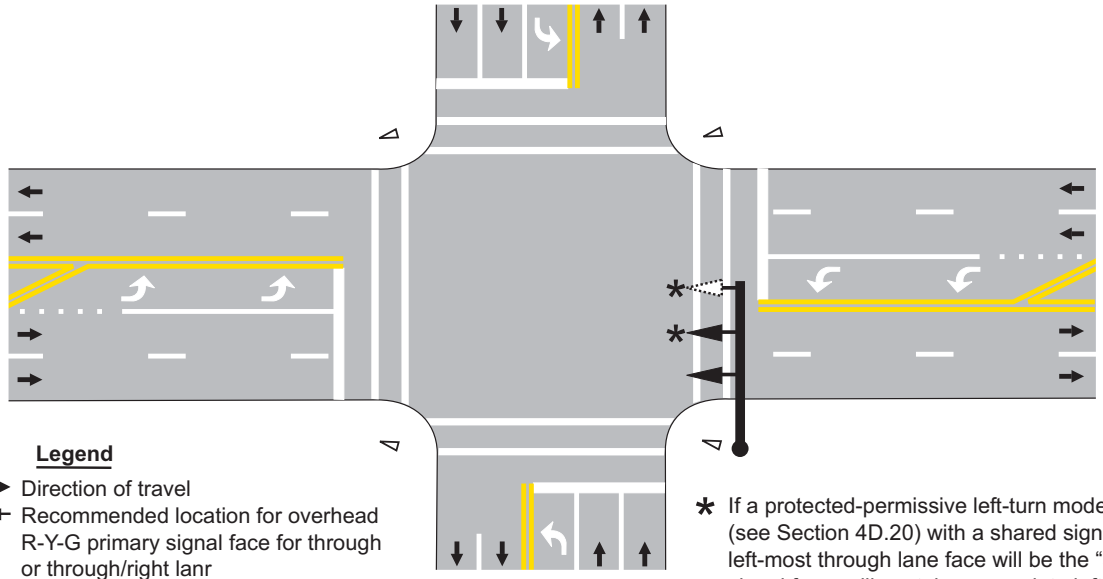
STANDARD:

The signal faces for each approach to an intersection or a mid-block location shall be provided as follows:

A. If a signalized through movement exists on an approach, a minimum of two primary signal faces shall be provided for the through movement. If a signalized through movement does not exist on an approach, a minimum of two primary signal faces shall be provided for the signalized turning movement that is considered to be the major movement from the approach (also see Section 4D.25).
B. See Section 4D.17 through 4D.20 for left-turn (and U-turn to the left) signal faces.
C. See Section 4D.21 through 4D.24 for right-turn (and U-turn to the right) signal faces.

OPTION:

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



Legend

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

* If a protected-permissive left-turn mode is used (see Section 4D.20) with a shared signal face, the left-most through lane face will be the "shared" signal face, will contain appropriate left-turn arrow indications in addition to circular R-Y-G, and will be located over the projection of the lane line between the left-turn and through lanes.

Notes:

1. Signal faces for only one direction and only one possible set of geometrics (number of lanes, etc.) are illustrated. If there are fewer or more than two through lanes on the approach, see Table 4D-2.
2. Any primary left-turn and/or right-turn signal faces, as determined by Sections 4D.17 through 4D.24, should be overhead for each exclusive turn lane.
3. One or more pole-mounted or overhead supplemental faces should be considered, based on the geometrics of the approach, to maximize visibility for approaching traffic.
4. All signal faces should have backplates.

Figure 4D-3. Recommended Signal Faces for Approaches with Posted, Statutory, or 85th Percentile Speed of 45 mph or Higher

SUPPORT:

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

GUIDANCE:

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

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

SUPPORT:

Locating primary signal faces overhead on the far side of the intersection has been shown to provide safer operation by reducing intersection entries late in the yellow interval and by reducing red signal violations, as compared to post-

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

NOTES: * A minimum of two through signal faces is always required (See Section 4D.11). These recommended numbers of through signal faces may be exceeded. Also, see cone of vision requirements otherwise indicated in Section 4D.13.
** If practical, all of the recommended number of primary through signal faces should be located overhead.

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

mounting signal faces at the roadside or locating signal faces overhead within the intersection on a diagonally-oriented mast arm or span wire. On approaches with two or more lanes for the through movement, one signal face per through lane, centered over each through lane, has also been shown to provide safer operation.

GUIDANCE:

If the posted or statutory speed limit or the 85th-percentile speed on an approach to a signalized location is 45 mph or higher, signal faces should be provided as follows for all new or reconstructed signal installations (see Figure 4D-3):

A. The minimum number and location of primary (non-supplemental) signal faces for through traffic should be provided in accordance with Table 4D-1.
B. If the number of overhead primary signal faces for through traffic is equal to the number of through lanes on an approach, one overhead signal face should be located approximately over the center of each through lane.
C. Except for shared left-turn and right-turn signal faces, any primary signal face required by Sections 4D.17 through 4D.25 for an exclusive turn lane should be located overhead approximately over the center of each exclusive turn lane.
D. All primary signal faces should be located on the far side of the intersection.
E. In addition to the primary signal faces, one or more supplemental pole-mounted or overhead signal faces should be considered to provide added visibility for approaching traffic that is traveling behind large vehicles.
F. All signal faces should have backplates.

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

4D.12 Visibility, Aiming, and Shielding of Signal Faces

STANDARD:

The primary consideration in signal face placement, aiming, and adjustment shall be to optimize the visibility of signal indications to approaching traffic.

Road users approaching a signalized intersection or other signalized area, such as a mid-block crosswalk, shall be given a clear and unmistakable indication of their right-of-way assignment.

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

GUIDANCE:

The two primary signal faces required as a minimum for each approach should be continuously visible to traffic approaching the traffic control signal, from a point at least

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

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

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

the minimum sight distance provided in Table 4D-2 in advance of and measured to the stop line. This range of continuous visibility should be provided unless precluded by a physical obstruction or unless another signalized location is within this range.

There should be legal authority to prohibit the display of any unauthorized sign, signal, marking, or device that interferes with the effectiveness of any official traffic control device (see Section 11-205 of the "Uniform Vehicle Code").

At signalized mid-block crosswalks, at least one of the signal faces should be over the traveled way for each approach.

STANDARD:

If approaching traffic does not have a continuous view of at least two signal faces for at least the minimum sight distance shown in Table 4D-2, a sign (see Section 2C.36)shall be installed to warn approaching traffic of the traffic control signal.

SUPPORT:

If a sign is installed to warn approaching road users of the traffic control signal, the sign may be supplemented by a Warning Beacon (see Section 4L.3).

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

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

GUIDANCE:

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

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

STANDARD:

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

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

GUIDANCE:

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

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

SUPPORT:

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

GUIDANCE:

If the posted or statutory speed limit or the 85th - percentile speed on an approach to a signalized location is 45 mph or higher, signal backplates should be used on all of

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

SUPPORT:

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

STANDARD:

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

SUPPORT:

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

4D.13 Lateral Positioning of Signal Faces

STANDARD:

At least one and preferably both of the minimum of two primary signal faces required for the through movement (or the major turning movement if there is no through movement) on the approach shall be located between two lines intersecting with the center of the approach at a point 10 feet behind the stop line, one making an angle of approximately 20 degrees to the right of the center of the approach extended, and the other making an angle of approximately 20 degrees to the left of the center of the approach extended The signal face that satisfies this requirement shall simultaneously satisfy the longitudinal placement requirement described in Section 4D.14 (see Figure 4D-4).

If both of the minimum of two primary signal faces required for the through movement (or the major turning movement if there is not through movement) on the approach are post-mounted, they shall both be on the far side of the intersection, one on the right and one on the left of the approach lane(s).

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

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

GUIDANCE:

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

SUPPORT:

Section 4D.11 contains additional provisions regarding lateral positioning of signal faces for approaches having a posted or statutory speed limit or an 85th-percentile speed of 45 mph or higher.

STANDARD:

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

Supplemental turn signal faces mounted over the roadway shall not be subject to the positioning requirements in the previous paragraph.

GUIDANCE:

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).

STANDARD:

If supplemental signal faces are used, the following limitations shall apply:

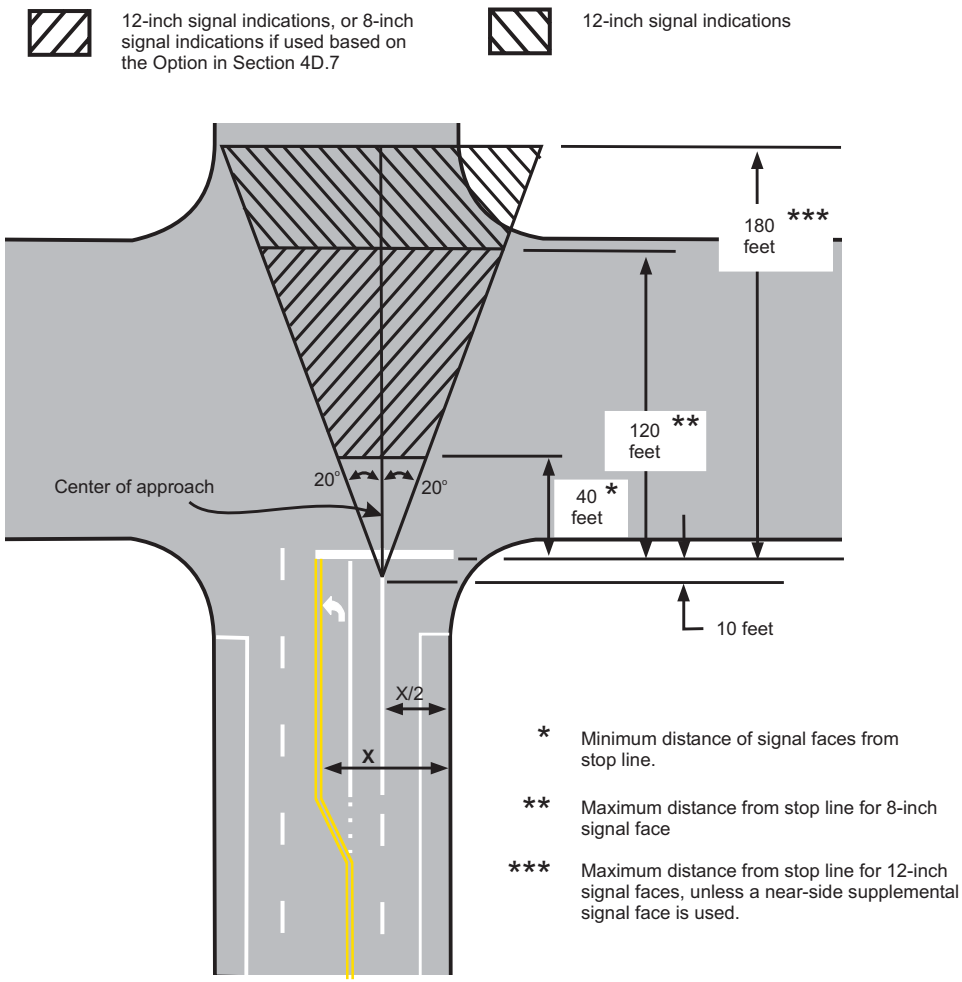
A. Left-turn arrows and U-turn arrows to the left shall not be used in near-right signal faces.
B. Right-turn arrows and U-turn arrows to the right shall not be used in far-left signal faces. A far-side median-mounted signal face shall be considered a far-left signal for this application.

4D.14 Longitudinal Positioning of Signal Faces

STANDARD:

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

Location of primary signal faces within these areas:



Notes:
1. See Section 4D.11 for approaches with posted, statutory, or 85th-percentile speeds of 45 mph or higher.
2. See Section 4D.13 regarding location of signal faces that display a CIRCULAR GREEN signal indication for a permissive left-turn movement on approaches with an exclusive left-turn lane or lanes.

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

A. A signal face installed to satisfy the requirements for primary left-turn signal faces (see Sections 4D.17 and 4D.20) and primary right-turn signal faces (see Sections 4D.21 through 4D.24), and at least one and preferably both of the minimum of two primary signal faces required for the through movement (or the major turning movement if there is no through movement) on the approach shall be located:
   1. No less than 40 feet beyond the stop line.
   2. No more than 180 feet beyond the stop line unless a supplemental near side signal face is provided.
   3. As near as practical to the line of the driver's normal view, if mounted over the roadway.

   The primary signal face that satisfies this requirement shall simultaneously satisfy the lateral placement requirement described in Section 4D.13 (see Figure 4D-4).

B. Where the nearest signal face is located between 150

and 180 feet beyond the stop line, engineering judgment of the conditions, including the worst-case visibility conditions, shall be used to determine if the provision of a supplemental near side signal face would be beneficial.

SUPPORT:

Section 4D.11 contains additional provisions regarding longitudinal positioning of signal faces for approaches having a posted or 85th-percentile speed of 45 mph or higher.

GUIDANCE:

Supplemental near-side signal faces should be located as near as practical to the stop line.

4D.15 Mounting Height of Signal Faces

STANDARD:

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

For viewing distances between 40 feet and 53 feet from the stop line, the maximum mounting height to the top of the signal housing shall be as shown on Figure 4D-5.

The bottom of the signal housing and any related attachments to a vehicular signal face located over any portion of a highway that can be used by motor vehicles shall be at least 17 feet and no more than 19 feet above the pavement.

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

A. Shall be a minimum of 8 feet and a maximum of 19 feet above the sidewalk or, if there is no sidewalk, above the pavement grade at the center of the roadway.
B. Shall be a minimum of 4.5 feet and a maximum of 19 feet above the median island grade of a center median island if located on the near side of the intersection.

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

A. Shall be a minimum of 8 feet and a maximum 22 feet above the sidewalk or, if there is no sidewalk, above the pavement grade at the center of the roadway.
B. Shall a minimum of 4.5 feet and a maximum 22 feet above the median island grade of a center median island if located on the near side of the intersection.

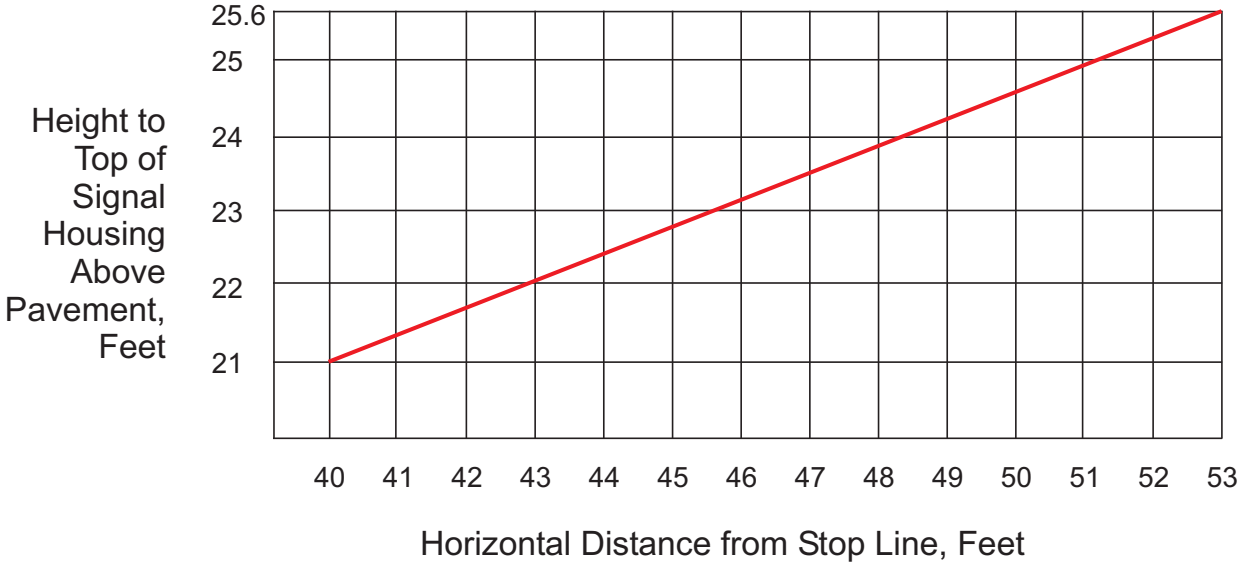


Figure 4D-5. Maximum Mounting Height of Signal Faces Located Between 40 Feet and 53 Feet from Stop Line

4D.16 Lateral Offset (Clearance) of Signal Faces

STANDARD:

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

4D.17 Signal Indications for Left Turn Movements - General

STANDARD:

In Sections 4D.17 through 4D.20, provisions applicable to left-turn movements and left-turn lanes shall also apply to signal indications for U-turns to the left that are provided at locations where left turns are prohibited or not geometrically possible.

SUPPORT:

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

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

OPTION:

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

STANDARD:

During a permissive left-turn movement, the signal faces for through traffic on the opposing approach shall simultaneously display green or steady yellow signal indications. If pedestrians crossing the lane or lanes used by the permissive left-turn movement to depart the intersection are controlled by pedestrian signal heads, the signal indications displayed by those pedestrian signal heads shall not be limited to any particular display during the permissive left-turn movement.

During a protected left-turn movement, the signal faces for through traffic on the opposing approach shall simultaneously display steady CIRCULAR RED signal indications. If pedestrians crossing the lane or lanes used by the protected left-turn movement to depart the intersection are controlled by pedestrian signal heads, the pedestrian signal heads shall display a steady UPRAISED HAND (symbolizing DONT WALK) signal indication during the protected left-turn movement.

A protected only mode left-turn movement that does not begin and terminate at the same time as the adjacent through movement shall not be provided on an approach unless an exclusive left-turn lane exists.

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

If the operating mode changes among the protected only mode and/or the protected/permissive mode and/or the permissive only mode during other different periods of the day or as traffic conditions change, the requirements in Sections 4D.18 through 4D.20 that are appropriate to that mode of operation shall be met, subject to the following:

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

OPTION:

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

SUPPORT:

Sections 4D.17 through 4D.20 describe the use of the following two types of signal faces for controlling left-turn movements:

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

provides protected/permissive mode left turns is mounted overhead at the intersection, it is usually positioned over or slightly to the right of the extension of the lane line separating the left-turn lane from the adjacent lane.

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

Section 4D.13 contains provisions regarding the lateral positioning of signal faces that control left-turn movements.

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

OPTION:

A signal face that is shared by left-turning and right-turning traffic may be provided for a shared left-turn/right-turn lane on an approach that has no through traffic (see Section 4D.25).

4D.18 Signal Indications for Permissive Only Mode Left-Turn Movements

STANDARD:

If a shared signal face is provided for a permissive only mode left turn, it shall meet the following requirements (see Figure 4D-6):

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

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

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

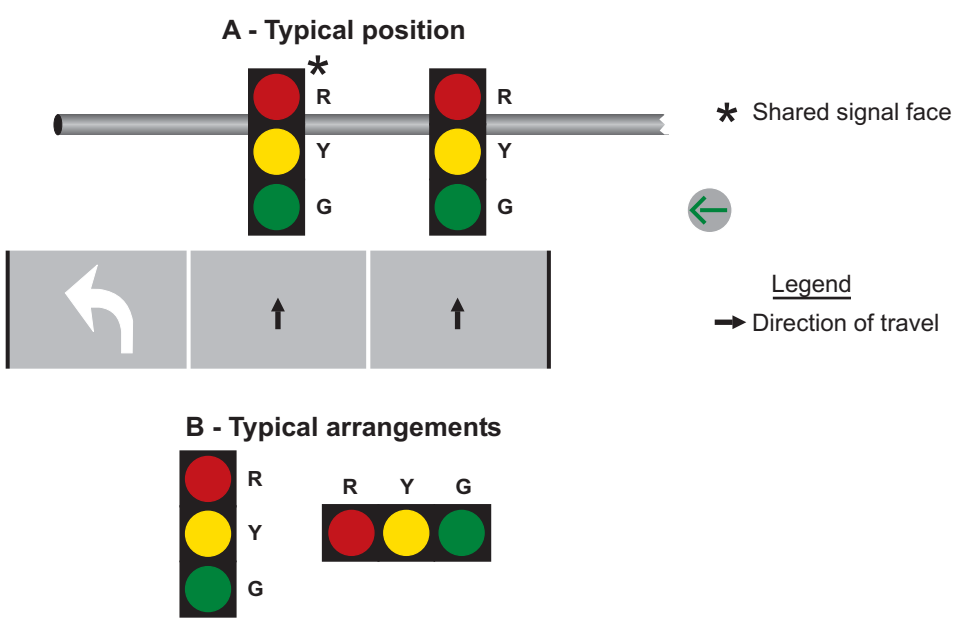


Figure 4D-6. Typical Position and Arrangements of Shared Signal Faces for Permissive Only Mode Left Turns

circular indication that the adjacent through signal face or faces display.

D. If the permissive only mode is not the only left-turn mode used for the approach, the signal face shall be the same shared signal face that is used for the protected/permissive mode (see Section 4D.20) except that the left-turn GREEN ARROW and left-turn YELLOW ARROW signal indications shall not be displayed when operating in the permissive only mode.

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

If a separate left-turn signal face is being operated in a permissive only left-turn mode and a flashing left-turn YELLOW ARROW signal indication is provided, it shall meet the following requirements (see Figure 4D-7):

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

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

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

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

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

F. During flashing mode operation (see Section 4D.30), the display of a flashing left-turn YELLOW ARROW signal indication shall be only from the signal section that displays a steady left-turn YELLOW ARROW signal indication during steady mode (stop-and-go) operation.

G. If the permissive only mode is not the only left-turn mode used for the approach, the signal face shall be the same separate left-turn signal face with a flashing

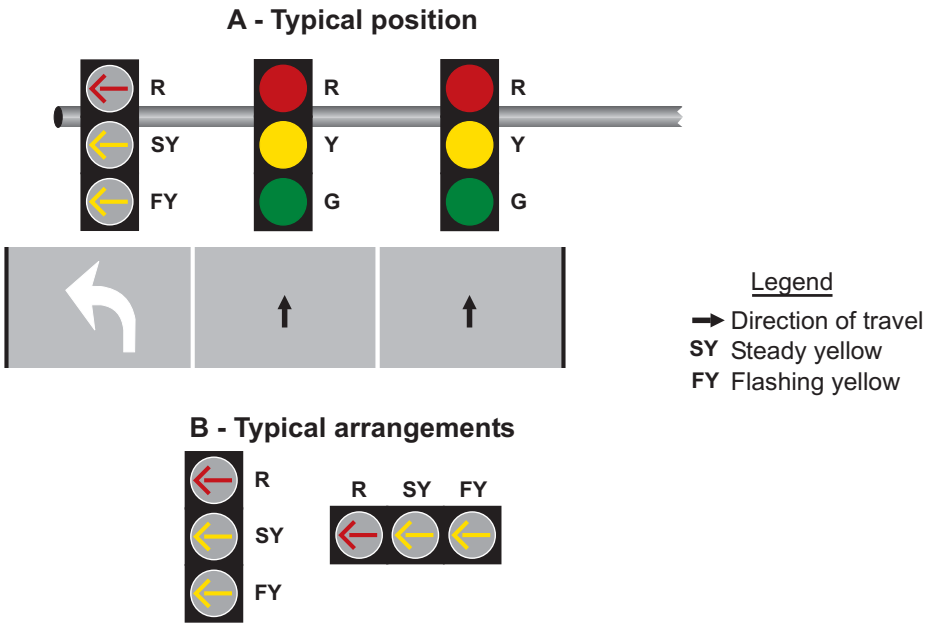


Figure 4D-7. Typical Position and Arrangements of Separate Signal Faces with Flashing Yellow Arrow for Permissive Only Mode Left Turns

YELLOW ARROW signal indication that is used for the protected/permissive mode (see Section 4D.20) except that the left-turn GREEN ARROW signal indication shall not be displayed when operating in the permissive only mode.

OPTION:

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

STANDARD:

If a separate left-turn signal face is being operated in a permissive only left-turn mode and a flashing left-turn RED ARROW signal indication is provided, it shall meet the following requirements (see Figure 4D-8):

A. It shall be capable of displaying the following signal indications: steady or flashing left-turn RED ARROW, steady left-turn YELLOW ARROW, and left-turn GREEN ARROW. Only one of the four indications shall be displayed at any given time. The GREEN ARROW indication is required in order to provide a three-section signal face, but shall not be displayed during the permissive only mode.

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

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

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

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

GUIDANCE:

The requirements of Item A above should be met by a vertically-arranged signal face with a horizontal cluster of two left-turn RED ARROW signal indications, the left-most of which displays a steady indication and the right-most of which displays a flashing indication (see Figure 4D-8).

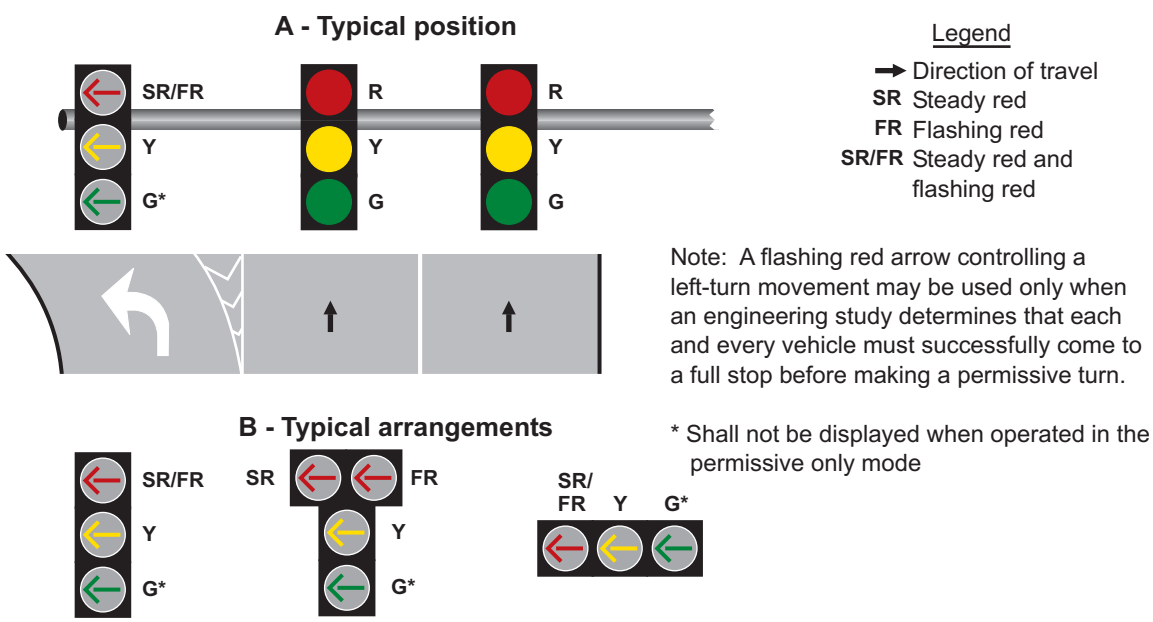


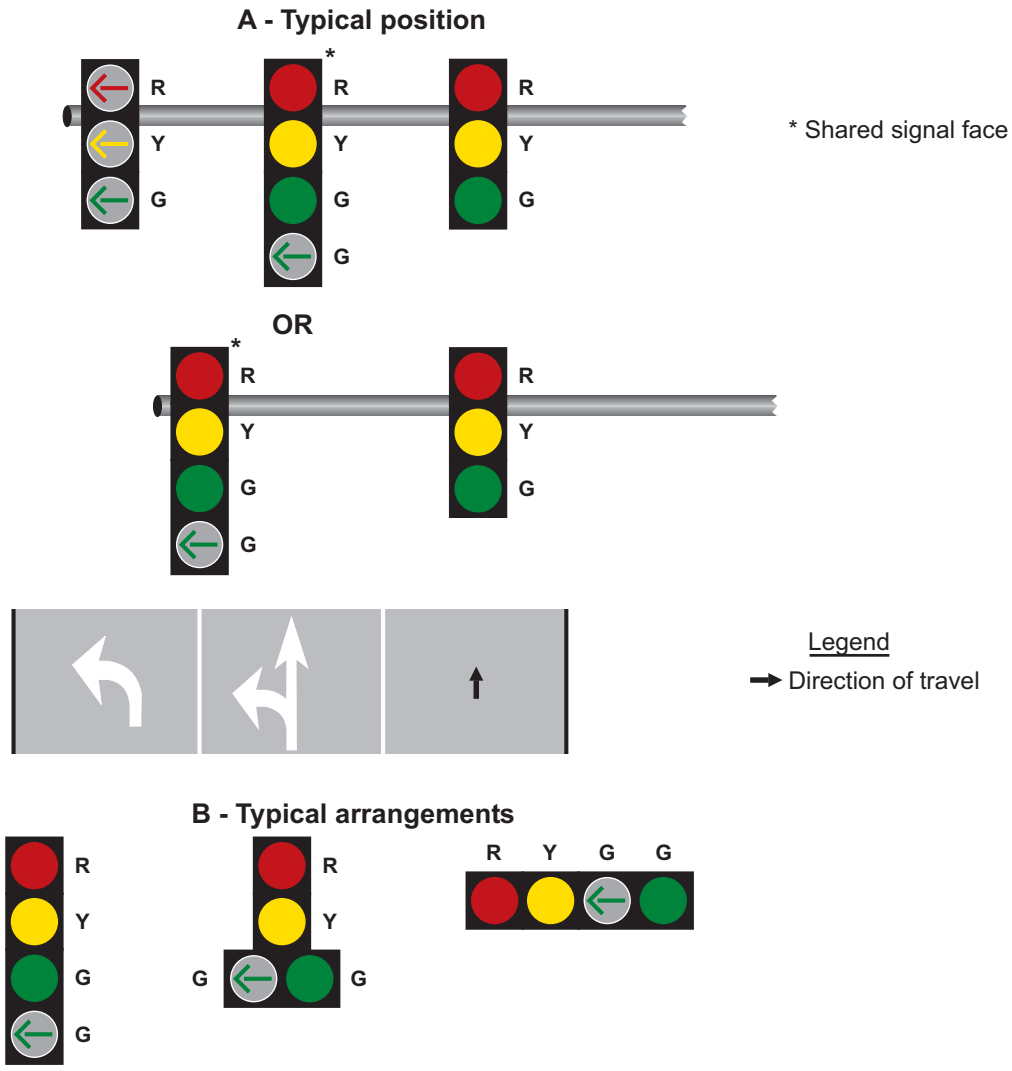
Figure 4D-8. Typical Position and Arrangements of Separate Signal Faces with Flashing Red Arrow for Permissive Only Mode and Protected/Permissive Mode Left Turns

4D.19 Signal Indications for Protected Only Mode Left-Turn Movements

STANDARD:

A shared signal face shall not be used for protected only mode left turns unless the CIRCULAR GREEN and left-turn GREEN ARROW signal indications always begin and terminate together. If a shared signal face is provided for a protected only mode left turn, it shall meet the following requirements (see Figure 4D-9):

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



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

Figure 4D-9. Typical Position and Arrangements of Shared Signal Faces for Protected Only Mode Left Turns

B. During the protected left-turn movement, the shared signal face shall simultaneously display both a CIRCULAR GREEN signal indication and a left-turn GREEN ARROW signal indication.
C. The shared signal face shall always simultaneously display the same color of circular indication that the adjacent through signal face or faces display.
D. If the protected only mode is not the only left-turn mode used for the approach, the signal face shall be the same shared signal face that is used for the protected/permissive mode (see Section 4D.20).

OPTION:

A straight-through GREEN ARROW signal indication may be used instead of the CIRCULAR GREEN signal indication in Items A and B in the previous Standard on an approach where right turns are prohibited and a straight-through GREEN ARROW signal indication is also used instead of a CIRCULAR GREEN signal indication in the other signal face(s) for through traffic.

STANDARD:

If a separate left-turn signal face is provided for a protected only mode left turn, it shall meet the following requirements (see Figure 4D-10):

A. It shall be capable of displaying, the following signal indications: steady left-turn RED ARROW, steady left-turn YELLOW ARROW, and left-turn GREEN ARROW. Only one of the three indications shall be displayed at any given time. A signal instruction sign shall not be required with this set of signal indications. If used, it shall be a LEFT ON GREEN ARROW ONLY sign (R10-5) (see figure 2B-27).
B. During the protected left-turn movement, a left-turn GREEN ARROW signal indication shall be displayed.
C. A steady left-turn YELLOW ARROW signal indication shall be displayed following the left-turn GREEN ARROW signal indication.
D. If the protected only mode is not the only left-turn mode used for the approach, the signal face shall be the same separate left-turn signal face that is used for the protected/permissive mode (see Section 4D.20 and Figures 4D-8 and 4D-12) except that the flashing left-turn YELLOW ARROW or flashing left-turn RED ARROW signal indication shall not be displayed when operating in the protected only mode.

4D.20 Signal Indications for Protected/ Permissive Mode Left-Turn Movements

STANDARD:

If a shared signal face is provided for a protected/permissive mode left turn, it shall meet the following requirements (see Figure 4D-11):

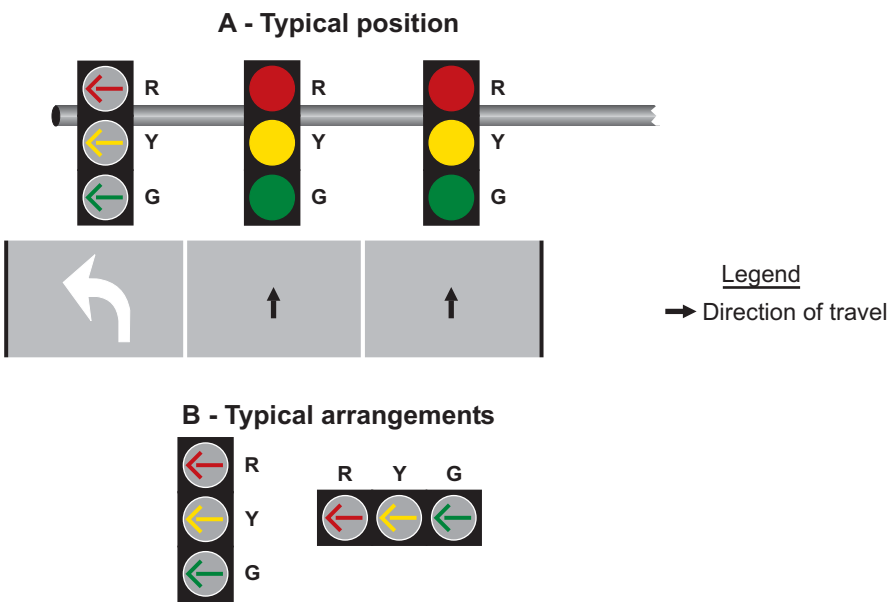


Figure 4D-10. Typical Position and Arrangements of Separate Signal Faces for Protected Only Mode Left Turns

A. It shall be capable of displaying the following signal indications: steady CIRCULAR RED, steady CIRCULAR YELLOW, CIRCULAR green, steady left-turn YELLOW ARROW, and left-turn GREEN ARROW. Only one of the three circular indications shall be displayed at any given time. Only one of the two arrow indications shall be displayed at any given time. If the left-turn GREEN ARROW signal indication and the CIRCULAR GREEN signal indication(s) for the adjacent through movement are always terminated together, the steady left-turn YELLOW ARROW signal indication shall not be required.

B. During the protected left-turn movement, the shared signal face shall simultaneously display a left turn GREEN ARROW signal indication and a circular signal indication that is the same color as the signal indication for the adjacent through lane on the same approach as the protected left turn.

C. A steady left-turn YELLOW ARROW signal indication shall be displayed following the left-turn GREEN ARROW signal indication, unless the left-turn GREEN ARROW signal indication and the CIRCULAR GREEN signal indication(s) for the adjacent through movement are being terminated together. When the left-turn GREEN ARROW and CIRCULAR GREEN signal indications are being terminated together, the required display following the left-turn GREEN ARROW signal indication shall be either the display of a CIRCULAR YELLOW signal indication alone or the simultaneous display of the CIRCULAR YELLOW and left-turn YELLOW ARROW signal indications.

D. During the permissive left-turn movement, the shared signal face shall display only a CIRCULAR GREEN signal indication.

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

F. A supplementary sign shall not be required. If used, it shall be a LEFT TURN YIELD ON GREEN (symbolic circular green) (R10-12) sign (see Figure 2B-27).

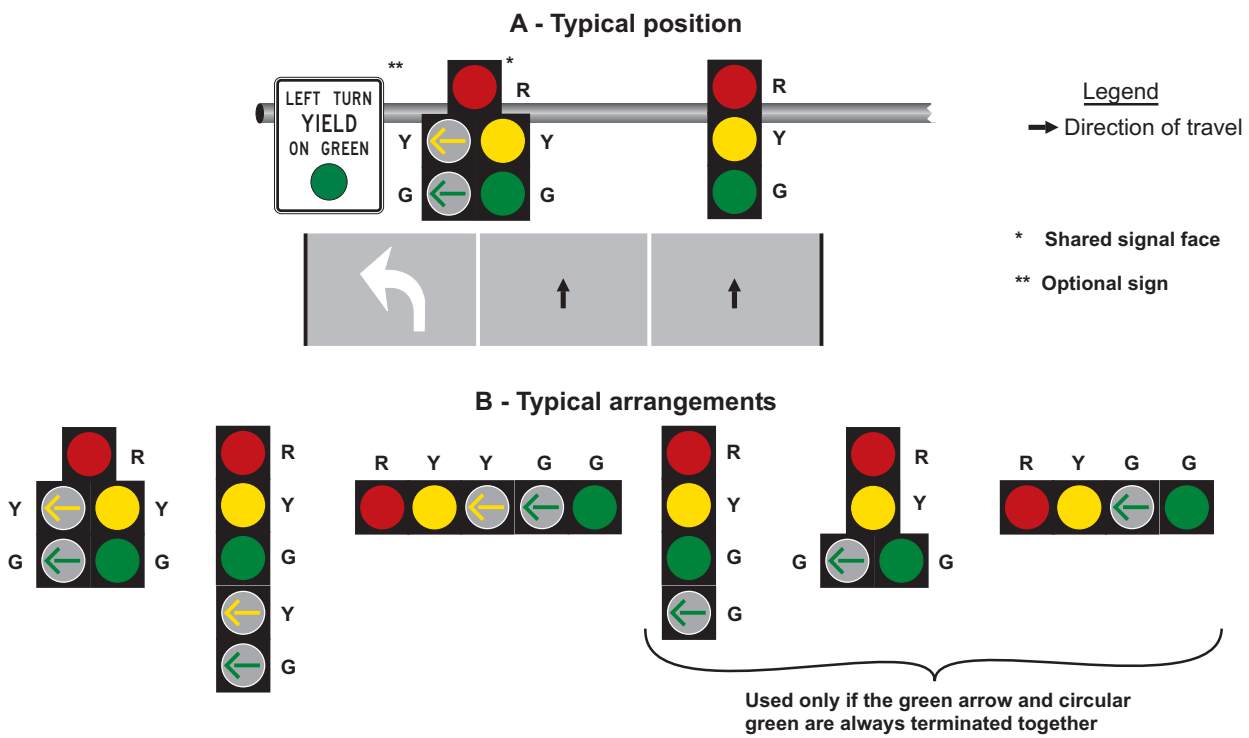


Figure 4D-11. Typical Position and Arrangements of Shared Signal Faces for Protected/Permissive Mode Left Turns

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

If a separate left-turn signal face is being operated in a protected/permissive left-turn mode and a flashing left-turn yellow arrow signal indication is provided, it shall meet the following requirements (see Figure 4D-12):

A. It shall be capable of displaying the following signal indications: steady left-turn RED ARROW, steady left-turn YELLOW ARROW, flashing left-turn YELLOW ARROW, and left-turn GREEN ARROW. Only one of the four indications shall be displayed at any given time.
B. During the protected left-turn movement, a left-turn GREEN ARROW signal indication shall be displayed.
C. A steady left-turn YELLOW ARROW signal indication shall be displayed following the left-turn GREEN ARROW signal indication.
D. During the permissive left-turn movement, a flashing left-turn YELLOW ARROW signal indication shall be displayed.
E. A steady left-turn YELLOW ARROW signal indication shall be displayed following the flashing left-turn YELLOW ARROW signal indication if the permissive left-turn movement is being terminated and the separate left-turn signal face will subsequently display a steady left-turn RED ARROW indication.
F. It shall be permitted to display a flashing left-turn YELLOW ARROW signal indication for a permissive left-turn movement while the signal faces for the adjacent through movement display steady CIRCULAR RED signal indications and the opposing left-turn signal faces display left-turn GREEN ARROW signal indications for a protected left-turn movement.
G. When a permissive left-turn movement is changing to a protected left-turn movement, a left-turn GREEN ARROW signal indication shall be displayed immediately upon the termination of the flashing left-turn YELLOW ARROW signal indication. A steady left-turn YELLOW ARROW signal indication shall not be displayed between the display of the flashing left-turn YELLOW ARROW signal indication and the display of the steady left-turn GREEN ARROW signal indication.
H. The display shall be a four-section signal face except that a three-section signal face containing a dual-

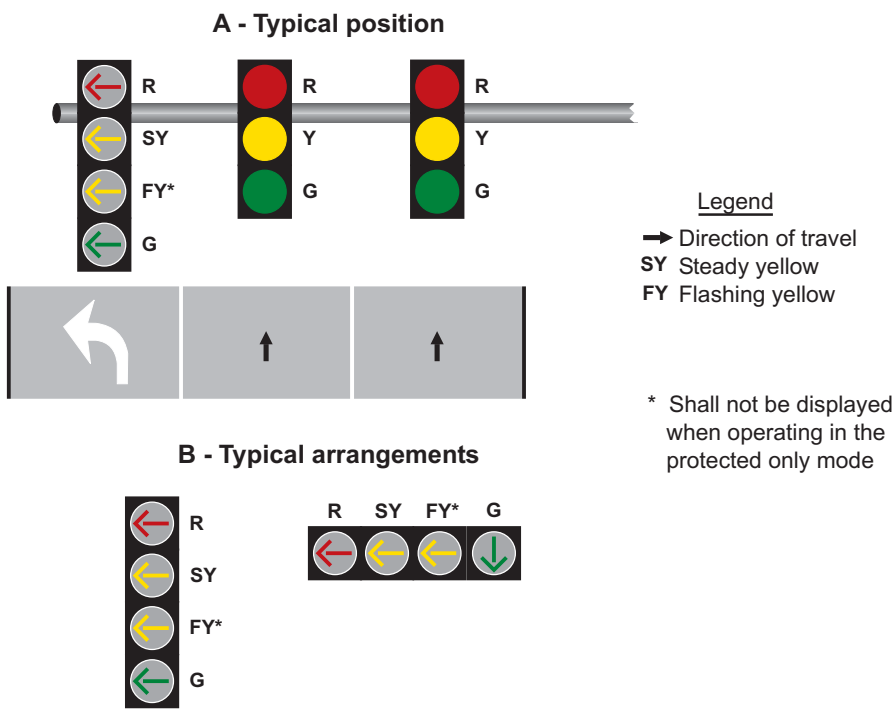


Figure 4D-12. Typical Position and Arrangements of Separate Signal Faces with Flashing Yellow Arrow for Protected/Permissive Mode and Protected Only Mode Left Turns

arrow signal section shall be permitted where signal head height limitations (or lateral positioning limitations for a horizontally-mounted signal face) will not permit the use of a four section signal face. The dual-arrow signal section, where used, shall display a GREEN ARROW for the protected left-turn movement and a flashing YELLOW ARROW for the permissive left-turn movement.

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

J. During flashing mode operation (see Section 4D.30), the display of a flashing left-turn YELLOW ARROW signal indication shall be only from the signal section that displays a steady left-turn YELLOW ARROW signal indication during steady mode (stop-and-go) operation.

OPTION:

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

STANDARD:

If a separate left-turn signal face is being operated in a protected/permissive left-turn mode and a flashing left-turn RED arrow signal indication is provided, it shall meet the following requirements (see Figure 4D-8):

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

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

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

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

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

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

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

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

GUIDANCE:

The requirements of Item A above should be met by a vertically-arranged signal face with a horizontal cluster of two left-turn RED ARROW signal indications, the left-most of which displays a steady indication and the right-most of which displays a flashing indication (see Figure 4D-8).

4D.21 Signal Indications for Right-Turn Movements - General

STANDARD:

In Sections 4D.21 through 4D.24, provisions applicable to right-turn movements and right-turn lanes shall also apply to signal indications for U-turns to the right that are provided at locations where right turns are prohibited or not geometrically possible.

SUPPORT:

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

A. Permissive Only Mode-turns made on a CIRCULAR GREEN signal indication, a flashing right-turn YELLOW ARROW signal indication, or a flashing right-turn RED ARROW signal indication after yielding to pedestrians, if any.

B. Protected Only Mode-turns made only when a right-turn GREEN ARROW signal indication is displayed.

C. Protected/Permissive Mode-both modes occur on an approach during the same cycle.

D. Variable Right-Turn Mode-the operating mode changes among the protected only mode and/or the protected/permissive mode and/or the permissive only mode during different periods of the day or as traffic conditions change.

STANDARD:

During a permissive right-turn movement, the signal faces, if any, that exclusively control U-turn traffic that conflicts with the permissive right-turn movement (see Item F.1 in Section 4D.5) shall simultaneously display steady U-turn RED ARROW signal indications. If pedestrians crossing the lane or lanes used by the permissive right-turn movement to depart the intersection are controlled by pedestrian signal heads, the signal indications displayed by those pedestrian signal heads shall not be limited to any particular display during the permissive right-turn movement.

During a protected right-turn movement, the signal faces for left-turn traffic, if any, on the opposing approach shall not simultaneously display a steady left-turn GREEN ARROW or steady left-turn YELLOW ARROW signal indication, and signal faces, if any, that exclusively control U-turn traffic that conflicts with the protected right-turn movement (see Item F.1 in Section 4D.5) shall simultaneously display steady U-turn RED ARROW signal indications. If pedestrians crossing the lane or lanes used by the protected right-turn movement to depart the intersection are controlled by pedestrian signal heads, the pedestrian signal heads shall display a steady UPRAISED HAND (symbolizing DONT WALK) signal indication during the protected right-turn movement.

A protected only mode right-turn movement that does not begin and terminate at the same time as the adjacent through movement shall not be provided on an approach unless an exclusive right-turn lane exists.

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

If the operating mode changes among the protected only mode and/or the protected/permissive mode and/or the permissive only mode during different periods of the day or as traffic conditions change, the requirements in Sections 4D.22 through 4D.24 that are appropriate to that mode of operation shall be met, subject to the following:

A. The CIRCULAR GREEN and CIRCULAR YELLOW signal indications shall not be displayed when operating in the protected only mode.
B. The right-turn GREEN ARROW and steady right-turn YELLOW ARROW signal indications shall not be displayed when operating in the permissive only mode except that a steady YELLOW ARROW may be displayed to indicate that the flashing YELLOW ARROW or flashing RED ARROW is being terminated.

OPTION:

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

SUPPORT:

Sections 4D.21 through 4D.24 describe the use of the following two types of signal faces for controlling right-turn movements:

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

Section 4D.13 contains provisions regarding the lateral positioning of signal faces that control right-turn movements.

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

OPTION:

A signal face that is shared by left-turning and right-turning traffic may be provided for a shared left-turn/right-turn lane on an approach that has no through traffic (see Section 4D.25).

4D.22 Signal Indications for Permissive Only Mode Right-Turn Movements

STANDARD:

If a shared signal face is provided for a permissive only mode right turn, it shall meet the following requirements (see Figure 4D-13):

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

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

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

D. If the permissive only mode is not the only right-turn mode used for the approach, the signal face shall be the same shared signal face that is used for the protected/permissive mode (see Section 4D.24) except that the right-turn GREEN ARROW and right-turn YELLOW ARROW signal indications shall not be displayed when operating in the permissive only mode.

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

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

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

1. Steady right-turn RED ARROW, steady right-turn YELLOW ARROW, and flashing right-turn YELLOW ARROW. Only one of the three indications shall be displayed at any given time.
2. Steady CIRCULAR RED, steady right-turn YELLOW ARROW, and flashing right-turn YELLOW ARROW. Only one of the three indications shall be displayed at any given time. If the CIRCULAR RED signal indication is sometimes displayed when the signal faces for the

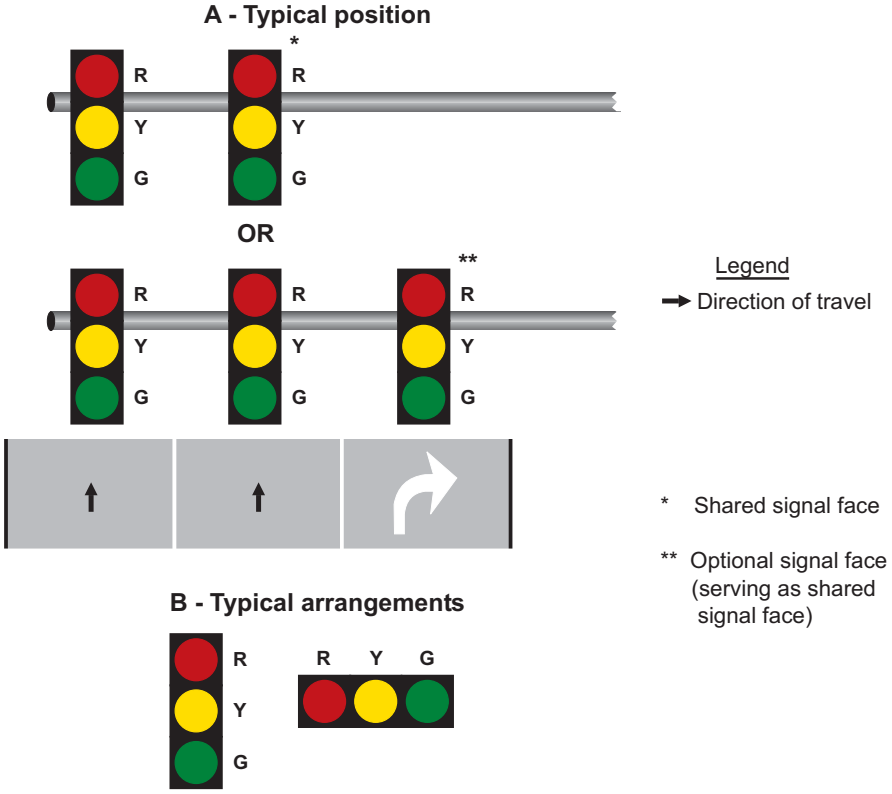


Figure 4D-13. Typical Position and Arrangements of Shared Signal Faces for Permissive Only Mode Right Turns

adjacent through lane(s) are not displaying a CIRCULAR RED signal indication, a RIGHT TURN SIGNAL (R10-10R) sign (see Figure 2B-27) shall be used unless the CIRCULAR RED signal indication in the separate right-turn signal face is shielded, hooded, louvered, positioned, or designed such that it is not readily visible to drivers in the through lane(s).

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

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

D. When the separate right-turn signal face is providing a message to stop and remain stopped, a steady right-turn RED ARROW signal indication shall be displayed if it is intended that right turns on red not be permitted or a steady CIRCULAR RED signal indication shall be displayed if it is intended that right turns on red be permitted.

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

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

G. During flashing mode operation (see Section 4D.30), the display of a flashing right-turn YELLOW ARROW signal indication shall be only from the signal section that displays a steady right-turn YELLOW ARROW signal indication during steady mode (stop-and-go) operation.

H. If the permissive only mode is not the only right-turn mode used for the approach, the signal face shall be the same separate right-turn signal face with a flashing YELLOW ARROW signal indication that is used for the protected/permissive mode (see Section 4D.24) except that the right-turn GREEN ARROW signal indication shall not be displayed when operating in the permissive only mode.

OPTION:

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

STANDARD:

If a separate right-turn signal face is being operated in a permissive only right-turn mode and a flashing right-turn RED arrow signal indication is provided, it shall meet the

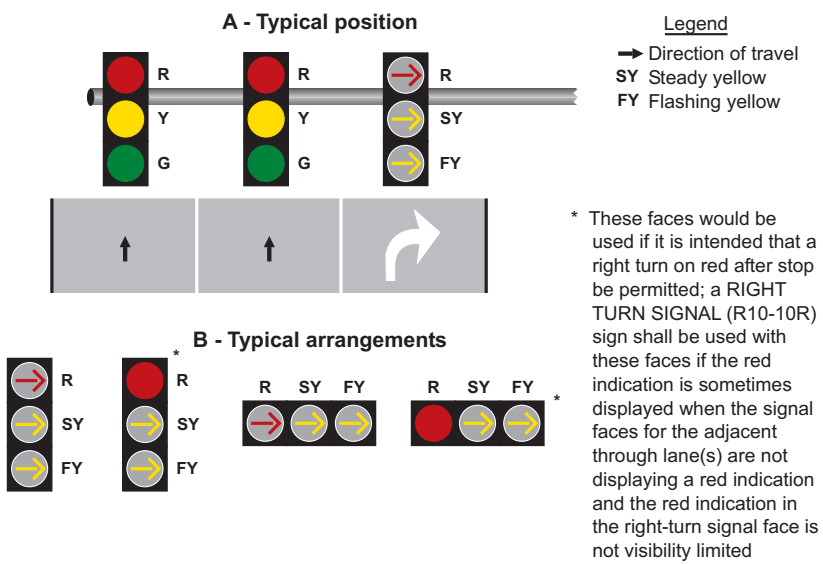


Figure 4D-14. Typical Position and Arrangements of Separate Signal Faces with Flashing Yellow Arrow for Permissive Only Mode Right Turns

following requirements (see Figure 4D-15):

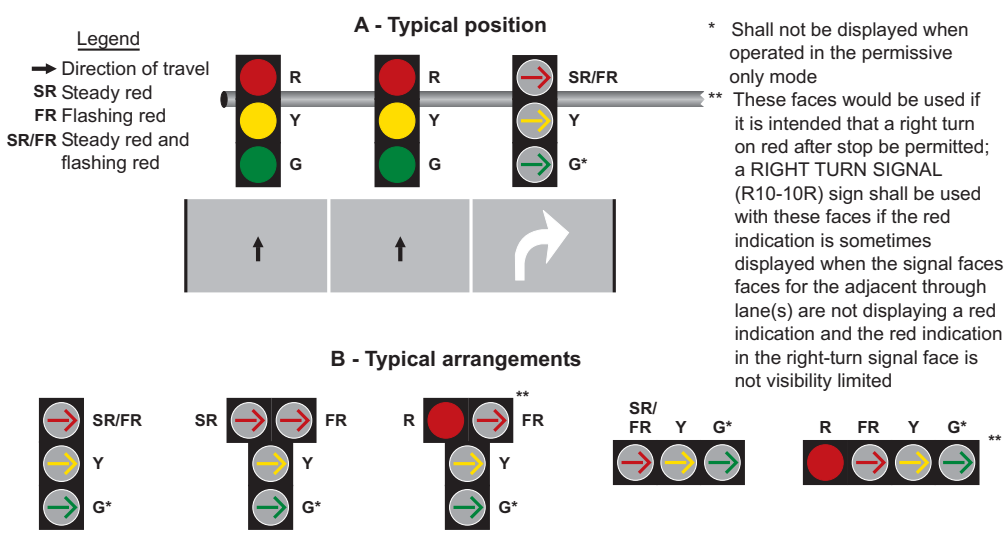
A. It shall be capable of displaying one of the following sets of signal indications:
   1. Steady or flashing right-turn RED ARROW, steady right-turn YELLOW ARROW, and right-turn GREEN ARROW. Only one of the three indications shall be displayed at any given time. The GREEN ARROW indication is required in order to provide a three-section signal face, but shall not be displayed during permissive only mode.
   2. Steady CIRCULAR RED on the left and steady right-turn RED ARROW on the right of the top position, steady right-turn YELLOW ARROW in the middle position, and right-turn GREEN ARROW in the bottom position. Only one of the four indications shall be displayed at any given time. The GREEN ARROW indication is required in order to provide three vertical positions, but shall not be displayed during permissive only mode. If the CIRCULAR RED signal indication is sometimes displayed when the signal faces for the adjacent through lane(s) are not displaying a CIRCULAR RED signal indication, a RIGHT TURN SIGNAL (R10-10R) sign (see Figure 2B-27) shall be used unless the CIRCULAR RED signal indication in the separate right-turn signal face is shielded, hooded, louvered, positioned, or designed such that it is not readily visible to drivers in the through lane(s).

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

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

D. When the separate right-turn signal face is providing a message to stop and remain stopped, a steady right-turn RED ARROW signal indication shall be displayed if it is intended that right turns on red not be permitted or a steady CIRCULAR RED signal indication shall be displayed if it is intended that right turns on red be permitted.

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



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

Figure 4D-15. Typical Position and Arrangements of Separate Signal Faces with Flashing Red Arrow for Permissive Only Mode and Protected/Permissive Mode Right Turns

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

GUIDANCE:

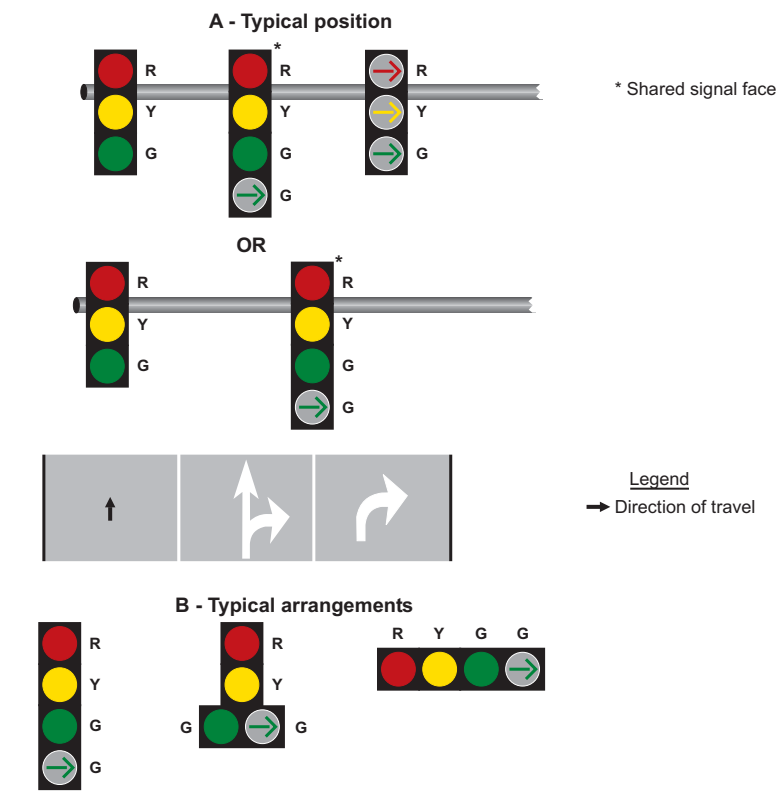
The requirements of Item A.1 above should be met by a vertically-arranged signal face with a horizontal cluster of two right-turn RED ARROW signal indications, the left-most of which displays a steady indication and the right-most of which displays a flashing indication (see Figure 4D-15).

4D.23 Signal Indications for Protected Only Mode Right-Turn Movements

STANDARD:

A shared signal face shall not be used for protected only mode right turns unless the CIRCULAR GREEN and right-turn GREEN ARROW signal indications always begin and terminate together. If a shared signal face is provided for a protected only right turn, it shall meet the following requirements (see Figure 4D-16):

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



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

Figure 4D-16. Typical Position and Arrangements of Shared Signal Faces for Protected Only Mode Right Turns

mode used for the approach, the signal face shall be the same shared signal face that is used for the protected/permissive mode (see Section 4D.24).

OPTION:

A straight-through GREEN ARROW signal indication may be used instead of the CIRCULAR GREEN signal indication in Items A and B in the previous Standard on an approach where left turns are prohibited and a straight-through

GREEN ARROW signal indication is also used instead of a CIRCULAR GREEN signal indication in the other signal face(s) for through traffic.

STANDARD:

If a separate right-turn signal face is provided for a protected only mode right turn, it shall meet the following requirements (see Figure 4D-17):

A. It shall be capable of displaying one of the following sets of signal indications:
   1. Steady right-turn RED ARROW, steady right-turn YELLOW ARROW, and right-turn GREEN ARROW. Only one of the three indications shall be displayed at any given time. A signal instruction sign shall not be required with this set of signal indications. If used, it shall be a RIGHT ON GREEN ARROW ONLY sign (R10-5a) (See Figure 2B-27) (See Section 2B.45).
   2. Steady CIRCULAR RED, steady right-turn YELLOW ARROW, and right-turn GREEN. Only one of three indications shall be displayed at any given time. If the CIRCULAR RED signal indication is sometimes displayed when the signal faces for the adjacent through lanes(s) are not displaying a CIRCULAR RED signal indication, a RIGHT TURN SIGNAL (R10-10R) sign (See Figure 2B-27) shall be used unless the CIRCULAR RED signal indication is shielded, hooded, louvered, positioned, or designed such that it is not readily visible to drivers in the through lane(s).

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

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

D. When the separate signal face is providing a message to stop and remain stopped, a steady right-turn RED ARROW signal indication shall be displayed if it is intended that right turns on red not be permitted or a steady CIRCULAR RED signal indication shall be displayed if it is intended that right turns on red be permitted.

E. If the protected only mode is not the only right-turn mode used for the approach, the signal face shall be the same separate right-turn signal face that is used for the protected/permissive mode (see Section 4D.24 and Figure 4D-19) except that a flashing right-turn YELLOW ARROW or flashing right-turn RED ARROW signal indication shall not be displayed when operating in the protected only mode.

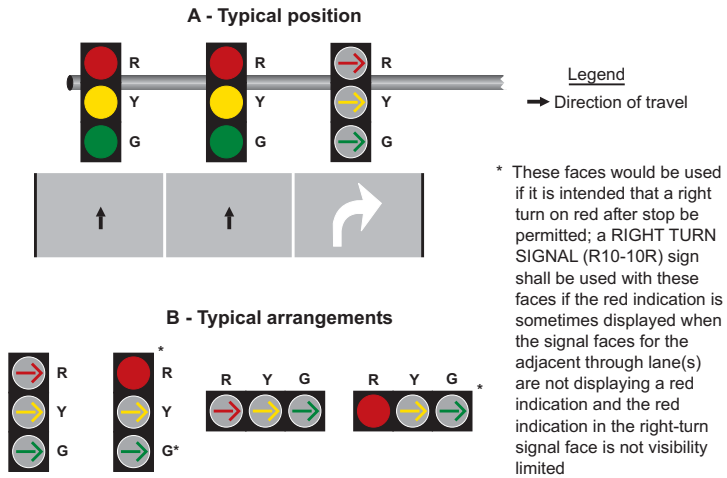


Figure 4D-17. Typical Position and Arrangements of Separate Signal Faces for Protected Only Mode Right Turns

4D.24 Signal Indications for Protected/Permissive Mode Right-Turn Movements

STANDARD:

If a shared signal face provided for a protected/permissive mode right turn, it shall meet the following requirements (see Figure 4D-18):

A. It shall be capable of displaying the following signal indications: steady CIRCULAR RED, steady CIRCULAR YELLOW, CIRCULAR green, steady right-turn YELLOW ARROW, and right-turn GREEN ARROW. Only one of the three circular indications shall be displayed at any given time. Only one of the two arrow indications shall be displayed at any given time. If the right-turn GREEN ARROW signal indication and the CIRCULAR GREEN signal indication(s) for the adjacent through movement are always terminated together, the steady right-turn YELLOW ARROW signal indication shall not be required.

B. During the protected right-turn movement, the shared signal face shall simultaneously display a right-turn GREEN ARROW signal indication and a circular signal indication that is the same color as the signal indication for the adjacent through lane on the same approach as the protected right turn.

C. A steady right-turn YELLOW ARROW signal indication shall be displayed following the right-turn GREEN ARROW signal indication, unless the right-turn GREEN ARROW signal indication and the CIRCULAR GREEN signal indication(s) for the adjacent through movement are being terminated together. When the right-turn GREEN ARROW and CIRCULAR GREEN signal indications are being terminated together, the required display following the right-turn GREEN ARROW signal indication shall be either the display of a CIRCULAR YELLOW signal indication alone or the simultaneous display of the CIRCULAR YELLOW and right-turn YELLOW ARROW signal indications.

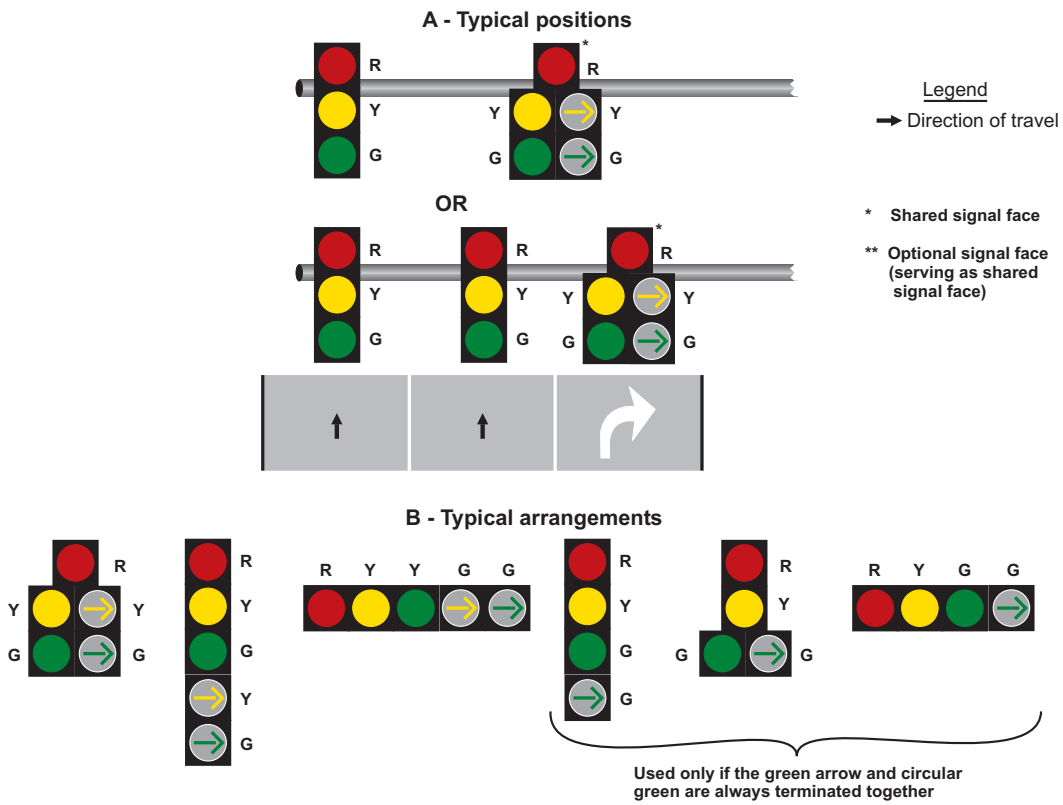


Figure 4D-18. Typical Positions and Arrangements of Shared Signal Faces for Protected/Permissive Mode Right Turns

D. During the permissive right-turn movement, the shared signal face shall display only a CIRCULAR GREEN signal indication.

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

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

If a separate right-turn signal face is being operated in a protected/permissive right-turn mode and a flashing right-turn yellow arrow signal indication is provided, it shall meet the following requirements (see Figure 4D-19):

A. It shall be capable of displaying one of the following sets of signal indications:
   1. Steady right-turn RED ARROW, steady right-turn YELLOW ARROW, flashing right-turn YELLOW ARROW, and right-turn GREEN ARROW. Only one of the four indications shall be displayed at any given time.
   2. Steady CIRCULAR RED, steady right-turn YELLOW ARROW, flashing right-turn YELLOW ARROW, and right-turn GREEN ARROW. Only one of the four indications shall be displayed at any given time. If the CIRCULAR RED signal indication is sometimes displayed when the signal faces for the adjacent through lane(s) are not displaying a CIRCULAR RED signal indication, a RIGHT TURN SIGNAL (R10-10R) sign (see Figure 2B-27) shall be used unless the CIRCULAR RED signal indication in the separate right-turn signal face is shielded, hooded, louvered, positioned, or designed such that it is not readily visible to drivers in the through lane(s).

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

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

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

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

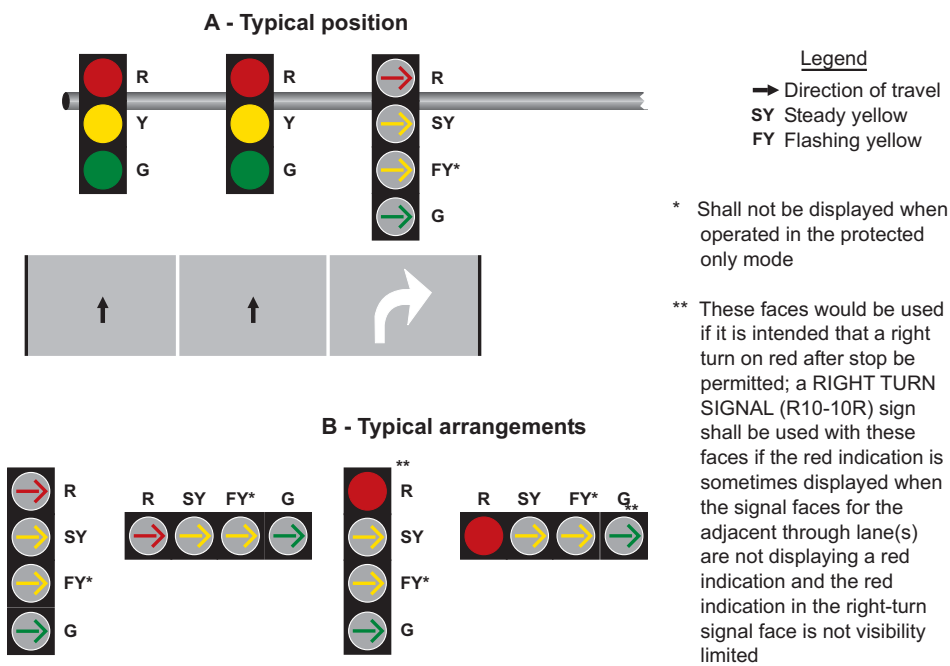


Figure 4D-19. Typical Position and Arrangements of Separate Signal Faces with Flashing Yellow Arrow for Protected/Permissive Mode and Protected Only Mode Right Turns

permissive right-turn movement is being terminated and the separate right-turn signal face will subsequently display a steady red indication.

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

G. When the separate right-turn signal face is providing a message to stop and remain stopped, a steady right-turn RED ARROW signal indication shall be displayed if it is intended that right turns on red not be permitted or a steady CIRCULAR RED signal indication shall be displayed if it is intended that right turns on red be permitted.

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

I. A signal face containing a dual-arrow signal section in place of separate flashing right-turn YELLOW ARROW and right-turn GREEN ARROW signal sections shall be permitted where signal head height limitations (or lateral positioning limitations for a horizontally-mounted signal face) are a concern. The dual-arrow signal section, where used, shall display a GREEN ARROW for the protected right-turn movement and a flashing YELLOW ARROW for the permissive right-turn movement.

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

K. During flashing mode operation (see Section 4D.30), the display of a flashing right-turn YELLOW ARROW signal indication shall be only from the signal section that displays a steady right-turn YELLOW ARROW signal indication during steady mode (stop-and-go) operation.

OPTION:

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

STANDARD:

If a separate right-turn signal face is being operated in a protected/permissive right-turn mode and a flashing right-turn RED arrow signal indication is provided, it shall meet the following requirements (see Figure 4D-15):

A. It shall be capable of displaying one of the following sets of signal indications:
   1. Steady right-turn RED ARROW, or flashing right-turn RED ARROW, steady right-turn YELLOW ARROW, and right-turn GREEN ARROW. Only one of the four indications shall be displayed at any given time.
   2. Steady CIRCULAR RED, or steady RED ARROW on the left and flashing right-turn RED ARROW on the right of the top position, steady right-turn YELLOW ARROW in the middle position, and right-turn GREEN ARROW in the bottom position. Only one of the four indications shall be displayed at any given time. If the CIRCULAR RED signal indication is sometimes displayed when the signal faces for the adjacent through lane(s) are not displaying a CIRCULAR RED signal indication, a RIGHT TURN SIGNAL (R10-10R) sign (see Figure 2B-27) shall be used unless the CIRCULAR RED signal indication in the separate right-turn signal face is shielded, hooded, louvered, positioned, or designed such that it is not readily visible to drivers in the through lane(s).

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

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

D. During the permissive right-turn movement, the separate right-turn signal face shall display a flashing right-turn RED ARROW signal indication.

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

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

G. When the separate right-turn signal face is providing a message to stop and remain stopped, a steady right-turn RED ARROW signal indication shall be displayed if it is intended that right turns on red not be permitted or a steady CIRCULAR RED signal indication shall be displayed if it is intended that right turns on red be permitted.

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

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

GUIDANCE:

The requirements of Item A.1 above should be met by a vertically-arranged signal face with a horizontal cluster of two right-turn RED ARROW signal indications, the left-most of which displays a steady indication and the right-most of which displays a flashing indication (see Figure 4D-15).

4D.25 Signal Indications for Approaches With Shared Left-Turn/Right-Turn Lanes and No Through Movement

SUPPORT:

A lane that is shared by left-turn and right-turn movements is sometimes provided on an approach that has no through movement, such as the stem of a T-intersection or where the opposite approach is a one-way roadway in the opposing direction.

STANDARD:

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

SUPPORT:

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

STANDARD:

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

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

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

1. A signal face(s) capable of displaying CIRCULAR RED, YELLOW ARROW, and GREEN ARROW signal indications for the exclusive turn lane(s), with the arrows pointing in the direction of the turn, and
2. A shared left-turn/right-turn signal face capable of displaying CIRCULAR RED, left-turn YELLOW ARROW, left-turn GREEN ARROW, right-turn YELLOW ARROW, and right-turn GREEN ARROW signal indications, in an arrangement of signal sections that complies with the provisions of Section 4D.09 or 4D.10.

C. If the approach has one or more exclusive turn lanes in addition to the shared left-turn/right-turn lane and there is a conflict with a signalized vehicular or pedestrian movement, and flashing YELLOW ARROW signal indications are used in place of CIRCULAR GREEN signal indications on the approach, the signal faces for the approach shall be as described in Items B.1 and B.2, except that flashing YELLOW ARROW signal indications shall be used in place of the GREEN ARROW signal indications for

A - No conflicting vehicular or pedestrian movements

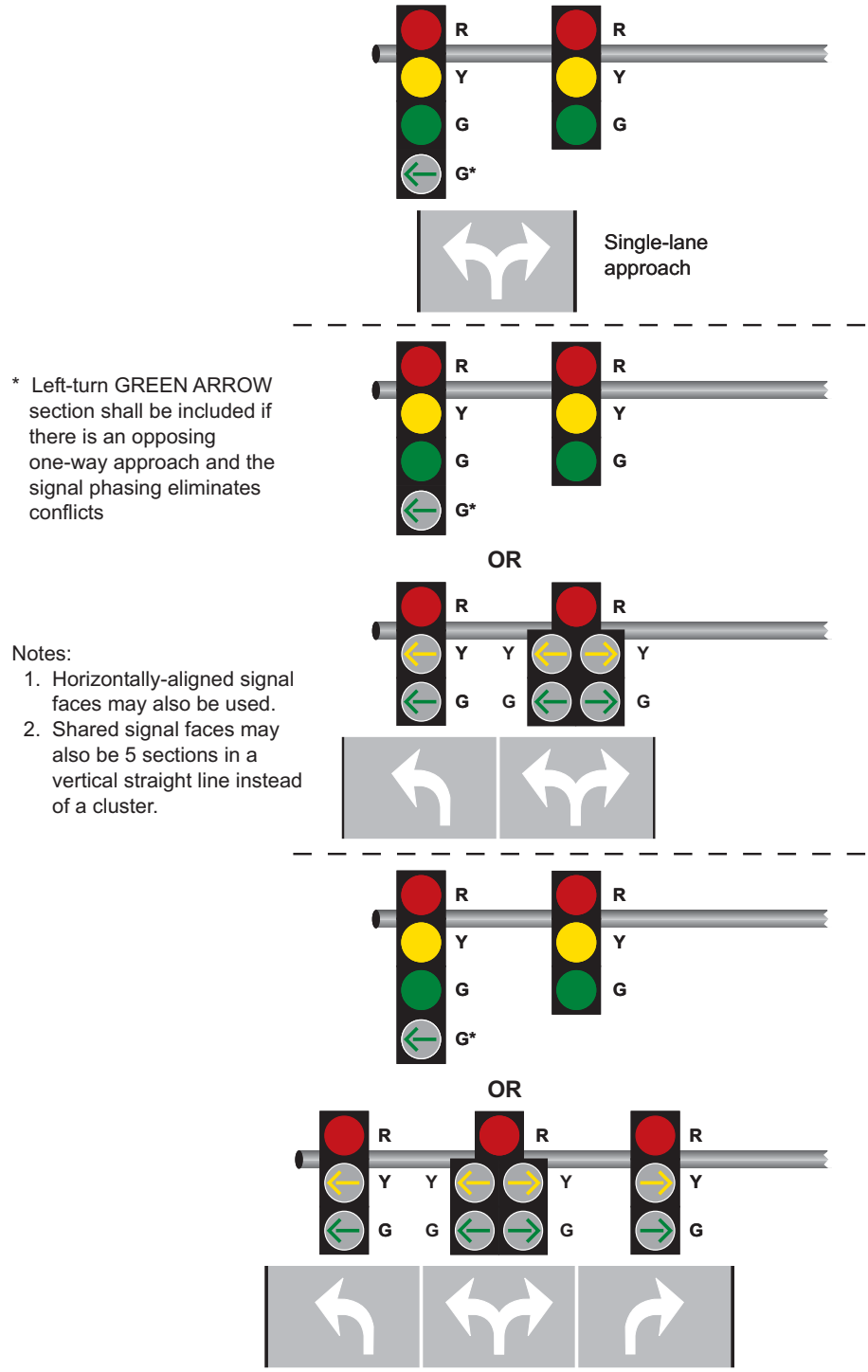


Figure 4D-20. Signal Indications for Approaches with a Shared Left-Turn/Right-Turn Lane and no Through Movement (Sheet 1 of 3)

B - Pedestrian or vehicular conflict with one turn movement

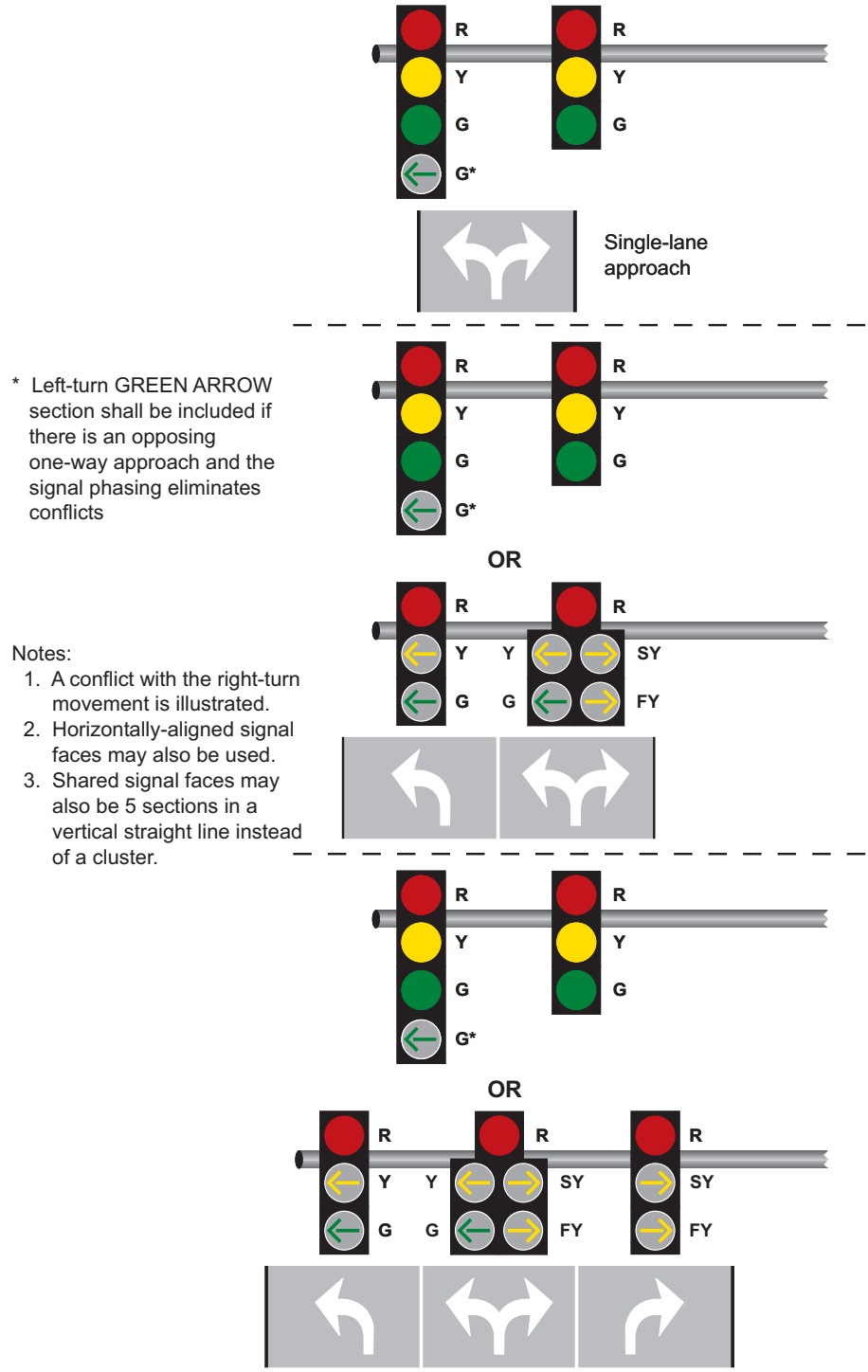
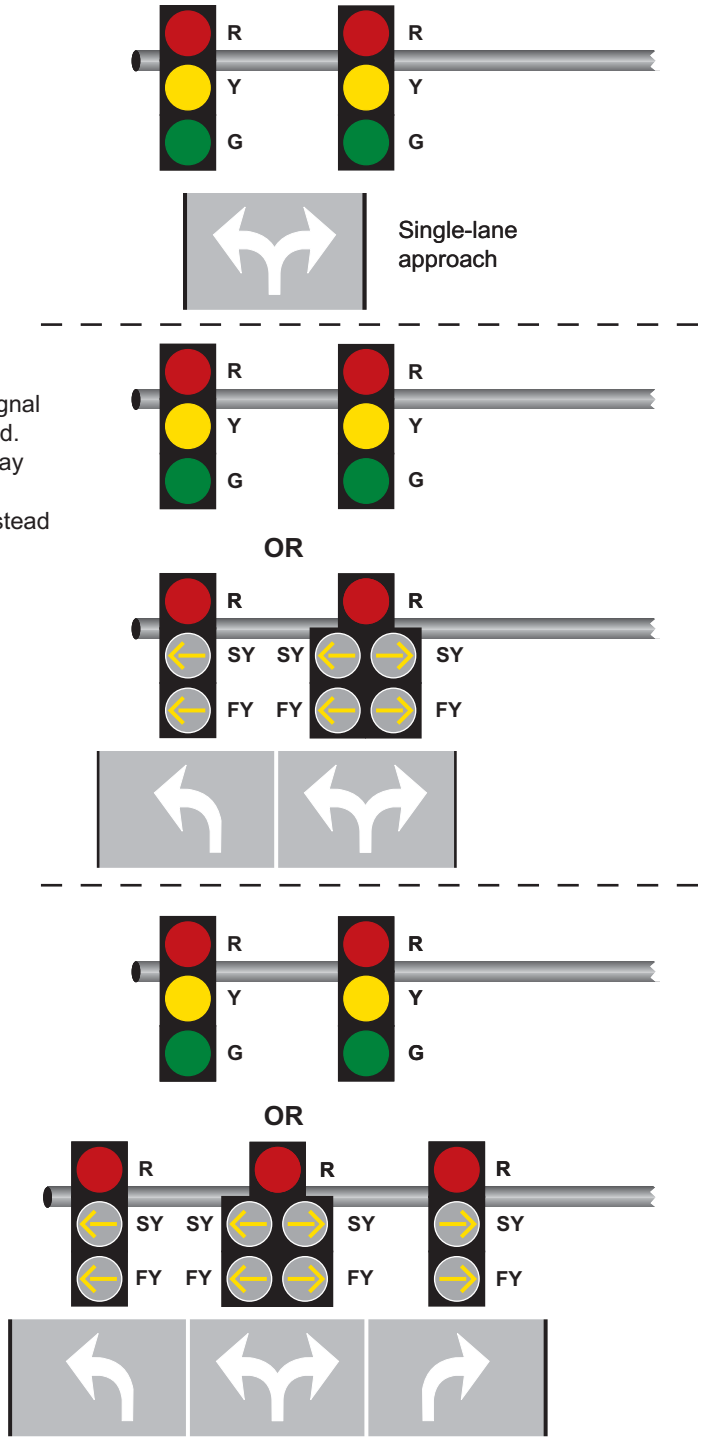


Figure 4D-20. Signal Indications for Approaches with a Shared Left-Turn/Right-Turn Lane and no Through Movement (Sheet 2 of 3)

C - Pedestrian or vehicular conflicts with both turn movements



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

Figure 4D-20. Signal Indications for Approaches with a Shared Left-Turn/Right-Turn Lane and no Through Movement (Sheet 3 of 3)

the turning movement(s) that conflicts with the signalized vehicular or pedestrian movement.

SUPPORT:

Figure 4D-20 illustrates application of these Standards on approaches that have only a shared left-turn/right-turn lane, and on approaches that have one or more exclusive turn lanes in addition to the shared left-turn/right-turn lane.

OPTION:

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

A. During the times that no lane is designated as a shared left-turn/right-turn lane, the left-turn and right-turn movements may start and terminate independently, and the left-turn and right-turn movements may be operated in one or more of the modes of operation as described in Sections 4D.17 through 4D.24; and

B. If a protected-permissive mode is used, the shared left-turn/right-turn signal face provided previously may be modified to include a dual-arrow signal section capable of displaying both a GREEN ARROW signal indication and a flashing YELLOW ARROW signal indication for a turn movement(s) in order to not exceed the maximum of five sections per signal face provided in Section 4D.8.

4D.26 Yellow Change and Red Clearance Intervals

STANDARD:

A steady yellow signal indication shall be displayed following every CIRCULAR GREEN or GREEN ARROW signal indication and following every flashing YELLOW ARROW or flashing RED ARROW signal indication displayed as a part of a steady mode operation. This requirement shall not apply when a CIRCULAR GREEN, a flashing YELLOW ARROW, or a flashing RED ARROW signal indication is followed immediately by a GREEN ARROW signal indication.

The exclusive function of the yellow change interval shall be to warn traffic of an impending change in the right-of-way assignment.

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

Compliance Date: June 13, 2017

MN Rev. 1

SUPPORT:

Section 4D.5 contains provisions regarding the display of steady CIRCULAR YELLOW signal indications to approaches from which drivers are allowed to make permissive left turns.

GUIDANCE:

When indicated by the application of engineering practices, the yellow change interval should be followed by a red clearance interval to provide additional time before conflicting traffic movements, including pedestrians, are released.

STANDARD:

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

Compliance Date: June 13, 2017

MN Rev. 1

SUPPORT:

Engineering practices for determining the duration of yellow change and red clearance intervals can be found in ITE's "Traffic Control Devices Handbook" and in ITE's "Manual of Traffic Signal Design" (see Section 1A.11).

STANDARD:

The durations of yellow change intervals and red clearance intervals shall be consistent with the determined values within the technical capabilities of the controller unit.

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

Except as provided in the following Option, the duration of a red clearance interval shall not be decreased or omitted on a cycle-by-cycle basis within the same signal timing plan.

OPTION:

The duration of a red clearance interval may be extended from its predetermined value for a given cycle based upon the detection of a vehicle that is predicted to violate the red signal indication.

When an actuated signal sequence includes a signal phase for permissive/protected (lagging) left-turn movements in both directions, the red clearance interval may be shown during those cycles when the lagging left-turn signal phase is skipped and may be omitted during those cycles when the lagging left-turn signal phase is shown.

The duration of a yellow change interval or a red clearance interval may be different in different signal timing plans for the same controller unit.

GUIDANCE:

A yellow change interval should have a minimum duration of 3 seconds and a maximum duration of 6 seconds. The longer intervals should be reserved for use on approaches with higher speeds.

Except when clearing a one-lane, two-way facility (see Section 4H.2) or when clearing an exceptionally wide intersection, a red clearance interval should have a duration not exceeding 6 seconds.

4. DETECTION

4.1 GENERAL

The purpose of this section is to familiarize the designer with the various operational components of both vehicular and pedestrian detectors. The factors which determine appropriate detection for a given area will be examined.

The control of traffic relates to the movement of vehicles and pedestrians. Since the volume of these movements generally varies at different times of the day, it is desirable to be able to detect approaching movements by placing one or more devices in the path of approaching vehicles or at a convenient location for the use of pedestrians.

4.2 PEDESTRIAN DETECTION

Pedestrian detection at actuated signals is typically accomplished through the use of pedestrian push buttons. Accessible pedestrian signal detectors, or devices to help pedestrians with visual or mobility impairments activate the pedestrian phase, may be pushbuttons or other passive detection devices. For pushbuttons to be accessible, they should be placed in accordance with the guidance in the MN MUTCD and located as follows (per MN MUTCD 4E.8):

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

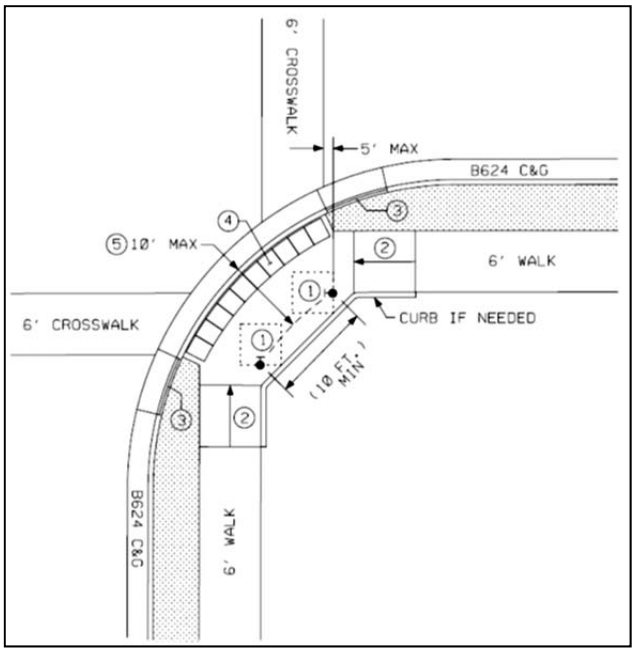
F. At a mounting height of approximately 3.5 feet, but no more than 4 feet, above the sidewalk.

Types of passive detection devices include, but are not limited to, video and infrared camera systems. Pedestrian detection can be helpful for assigning right-of-way when installed at locations with high demands of both pedestrian and vehicle volumes. As one form of transportation demand increases over another, the detection can instruct the signal controller to give precedence to the higher demand. Pedestrian detection may also allow for detection of users that will require extended walk times. Alternative methods of pedestrian detection, including infrared and microwave detectors, are emerging.

4.2.1 Accessible Pedestrian Signals (APS)

Accessible Pedestrian Signal is a device that communicates information about pedestrian timing in nonvisual format such as audible tones, verbal messages, and/or vibrating surfaces. **APS is required for all major signal revisions on Trunk Highways**.

There are a number of traffic signal design issues to consider for Accessible Pedestrian Signals (APS).



- ADA guidelines require the buttons to be a minimum of 10' apart.
- If you are designing a new signal, do not design a pole or station with two APS buttons on it. Put one on the pole and one on the push button station; or two push button stations if the pole isn't located properly. **Strongly** avoid installing two APS buttons on the same push button station.
- An easily replaceable APS pushbutton station detail is on the OTST web site. Use this detail if installing an APS pushbutton station.
- When designing a new corner with APS for each of the two directions, design it with two pedestrian stations. If after the initial construction the signal pole is found to be in an acceptable location, the APS can be placed on the signal pole and one of the pedestrian stations can be omitted. The contractor shall then give the unused pedestrian station to MnDOT.
- Use the guidelines in the special provisions for programming
- APS pushbutton is an evolving component. Future changes and design practices will happen.
- Since each APS button at an intersection may have a unique message, each button must have an individual identifiable address such as A1, A2, B1, etc. (see page **6-28**).
- **It is imperative to work with the roadway designer to consider APS requirements**.

Additional details regarding the design of APS can be found on page 6-43. Also refer to the MN MUTCD regarding Pedestrian Control Features.

MnDOT has a new detail for a pedestrian push button stations and building pedestrian ramps. There is an 11” x 17” copy of this in the appendix. Standard Plan 5-297.250 (5 sheets) must be included in plans that have APS. The current version of the standard plans can be found at:

http://standardplans.dot.state.mn.us/

A Guide to APS Best Practices can be found by visiting the following site:

www.apsguide.org/index.cfm

4.3 DRAFT ACCESSIBLE GUIDELINES

The information following this sheet is a handout taken from the NOTICE OF AVAILABILITY OF DRAFT PUBLIC RIGHTS-OF-WAY ACCESSIBILITY GUIDELINES.

These guidelines can be found at:

http://www.access-board.gov/prowac/

In addition, Technical Memorandum No. 10-02-TR-01 adopting the guidelines is included. This adoption excludes the section on signals at multi-lane roundabouts.

Note: It is recommended that you review all original reference material.

51 to 75	3
76 to 100	4
101 to 150	5
151 to 200	6
201 and over	4% of total

R217 Passenger Loading Zones
Where passenger loading zones are provided, a minimum of one passenger loading zone complying with R412 shall be provided in every continuous 30 m (100 ft) of loading zone space or fraction thereof.

R218 Call Boxes
Where provided, roadside call boxes shall comply with R309.

R219 Transit Platforms
Where provided, transit platforms shall comply with R414.

R220 Escalators
Where provided, escalators shall comply with sections 6.1.3.5.6 and 6.1.3.6.5 of ASME A17.1 (incorporated by reference; see 104.2.2).

R221 Detectable Warning Surfaces
Detectable warning surfaces shall comply with R304.

Advisory R221 Detectable Warning Surfaces. Detectable warning surfaces are required where curb ramps, blended transitions, or landings provide a flush pedestrian connection to the street. Sidewalk crossings of residential driveways should not generally be provided with detectable warnings, since the pedestrian right-of-way continues across most driveway aprons and overuse of detectable warning surfaces should be avoided in the interests of message clarity. However, where commercial driveways are provided with traffic control devices or otherwise are permitted to operate like public streets, detectable warnings should be provided at the junction between the pedestrian route and the street.

R222 Doors, Doorways, and Gates
Where provided, doors, doorways, and gates shall comply with R411.

CHAPTER R3: TECHNICAL PROVISIONS

R301 Pedestrian Access Route

R301.1 General. Pedestrian access routes shall comply with R301 and shall connect pedestrian elements and facilities required to be accessible.

R301.2 Components. Pedestrian access routes shall consist of one or more of the following components: walkways, ramps, curb ramps (excluding flared sides) and landings, blended transitions, crosswalks, and pedestrian overpasses and underpasses, elevators, and platform lifts. Stairways and escalators shall not be part of a pedestrian access route. All components of a pedestrian access route shall comply with the applicable portions of this document.

R301.3 Width.

R301.3.1 Continuous Width. The minimum continuous and unobstructed clear width of a pedestrian access route shall be 1.2 m (4.0 ft), exclusive of the width of the curb.

Advisory R301.3.1 Continuous Width. The pedestrian access route provides a minimum accessible route of passage within a sidewalk or other walkway that may not comprise the full width of the pedestrian circulation route, particularly in urban areas. Industry-recommended sidewalk widths can be found in 'Guide for the Planning, Design, and Operation of Pedestrian Facilities', American Association of State Highway and Transportation Officials, July 2004 (www.aashto.org). The minimum width must be maintained without obstruction.

Where a pedestrian access route turns or changes direction, it should accommodate the continuous passage of a wheelchair or scooter. As with street or highway design for vehicles, additional maneuvering width or length may be needed at recesses and alcoves, doorways and entrances, and along curved or angled routings, particularly where the grade exceeds 5%. Individual segments of pedestrian access routes should have a minimum straight length of 1.2 m (4.0 ft).

Street furniture, including fixed or movable elements such as newspaper and sales racks, cafe seating and tables, bus shelters, vender carts, sidewalk sculptures, and bicycle racks, shall not reduce the required width of the pedestrian access route.

Provisions for protruding objects apply across the entire width of the pedestrian circulation path, not just the pedestrian access route.

R301.3.2 Width at Passing Spaces. Walkways in pedestrian access routes that are less than 1.5 m (5.0 ft) in clear width shall provide passing spaces at intervals of 61 m (200 ft) maximum. Pedestrian access routes at passing spaces shall be 1.5 m (5.0 ft) wide for a distance of 1.5m (5.0 ft).

R301.3.3 Width at Elevators and Lifts. The pedestrian access route at elevators and platform lifts shall be permitted to comply with the applicable requirements of section 407, 408, and 410 of Appendix D to 36 CFR part 1191 (the ADA and ABA Accessibility Guidelines).

R301.3.4 Width at Doors, Doorways, and Gates. The pedestrian access route through doors, doorways, and gates shall be permitted to comply with R411.2.3.

R301.4 Walkway Grade and Cross Slope.

R301.4.1 Cross Slope. The cross slope of the walkway of a pedestrian access route shall be 2 percent maximum.

R301.4.2 Street or Highway Grade. Where the walkway of a pedestrian access route is contained within a street or highway border, its grade shall not exceed the general grade established for the adjacent street or highway.

R301.4.3 Supported Slope. Where the walkway of a pedestrian access route is supported by a structure, it shall comply with R305.5.

Advisory R301.4.3 Supported Slope. This provision covers pedestrian access routes on bridges, overpasses, underpasses and similar facilities.

R301.5 Surface. The surface of the pedestrian access route shall be firm, stable and slip resistant.

Advisory R301.5 Surface. The U.S. Department of Justice ADA regulations require that the usability of accessible features be maintained (28 CFR §35.133 and §36.211).-

R301.5.1 Vertical Alignment. Vertical alignment shall be planar within curb ramp runs, blended transitions, landings, and gutter areas within the pedestrian access route, and within clear spaces required for accessible pedestrian signals, street furniture, and operable parts. Grade breaks shall be flush. Where the pedestrian access route crosses rail tracks at grade, the surface of the pedestrian access route shall be level and flush with the top of the rail at the outer edges of the rail. The surface between the rails shall be aligned with the top of the rail.

R301.5.2 Surface Discontinuities. Surface discontinuities shall not exceed 13 mm (0.50 in) maximum. Vertical discontinuities between 6.4 mm (0.25 in) and 13 mm (0.5 in) maximum shall be beveled at 1:2 minimum. The bevel shall be applied across the entire level change.

Advisory R301.5.2 Surface Discontinuities. Surfaces with individual units laid out of plane and those that are heavily textured, rough, or chamfered, will greatly increase rolling resistance and will subject pedestrians who use wheelchairs, scooters, and rolling walkers to the stressful (and often painful) effects of vibration. It is highly desirable to minimize surface discontinuities; when discontinuities on the pedestrian access route are unavoidable, they should be widely separated.

R301.7 Horizontal Openings.

R301.7.1 Walkway Joints and Gratings. Openings shall not permit passage of a sphere more than 13 mm (0.5 in) in diameter. Elongated openings shall be placed so that the long dimension is perpendicular to the dominant direction of travel.

R301.7.2 Clearances at Elevator and Platform Lift Sills. Clearances between elevator car platform sills and associated hoistways and between a platform lift sill and any landing shall comply with the applicable requirements in sections 407.4.3, 408.4.3, and 410.4 of Appendix D to 36 CFR part 1191 (the ADA and ABA Accessibility Guidelines).

R301.7.3 Flangeway Gaps at Non-Freight Rail Crossings. Openings for wheel flanges at pedestrian crossings of non-freight rail track shall be 64 mm (2.5 in) maximum.

R301.7.4 Flangeway Gaps at Freight Rail Crossings. Openings for wheel flanges at pedestrian crossings of freight rail track shall be 75 mm (3 in) maximum.

R302 Alternate Circulation Path

R302.1 General. Alternate circulation paths shall comply with R302 and shall contain a pedestrian access route complying with R301.

Advisory R302.1 General. Temporary routes are alterations to an existing developed pedestrian environment and are required to achieve the maximum accessibility feasible under existing conditions.

R302.2 Location. To the maximum extent feasible, the alternate circulation path shall be provided on the same side of the street as the disrupted route.

Advisory R302.2 Location. Where it is not feasible to provide a same-side alternate circulation path and pedestrians will be detoured, section 6D.02 of the MUTCD specifies that the alternate path provide a similar level of accessibility to that of the existing disrupted route. This may include the incorporation of accessible pedestrian signals (APS), curb ramps, or other accessibility features.

R302.3 Protection. Where the alternate circulation path is exposed to adjacent construction, excavation drop-offs, traffic, or other hazards, it shall be protected with a pedestrian barricade or channelizing device complying with R302.4.

Advisory R302.3 Protection. When it is necessary to block travel at the departure curb to close a crosswalk that is disrupted by excavation, construction, or construction activity, care must be taken to preserve curb ramp access to the perpendicular crosswalk. This may require additional pedestrian channelization if only a single diagonal curb ramp

serves the corner.

Figures 6H-28 and 6H-29 of the MUTCD specify notification signage for pedestrian closings and detours. Audible signage triggered by proximity switches can provide information to pedestrians who do not use print signs.

R302.4 Pedestrian Barricades and Channelizing Devices. Pedestrian barricades and channelizing devices shall be continuous, stable, and non-flexible and shall consist of a wall, fence, or enclosures specified in section 6F-58, 6F-63, and 6F-66 of the MUTCD (incorporated by reference; see R104.2.4).

R302.4.1 Detectable Base. A continuous bottom edge shall be provided 150 mm (6 in) maximum above the ground or walkway surface.

R302.4.2 Height. Devices shall provide a continuous surface or upper rail at 0.9 m (3.0 ft) minimum above the ground or walkway surface. Support members shall not protrude into the alternate circulation path.

R303 Curb Ramps and Blended Transitions

R303.1 General. Curb ramps and blended transitions shall comply with R303.

Advisory R303.1 General. Curb ramps can be a key source of wayfinding information for pedestrians who travel without vision cues if they are installed in-line with the direction of pedestrian travel at crossings. This is most easily accomplished by locating the ramp at the tangent point of the curb return, using either a small curb radius in an attached sidewalk or, in larger radii, a border or setback from the street edge. The Institute of Transportation Engineers (www.ite.org) has undertaken an industry-wide effort to develop and standardize intersection plans that optimize wayfinding. The challenge for practitioners is to provide usability for pedestrians in wheelchairs and scooters with a rectangular ramp plan that can also be directional.

R303.2 Types. Perpendicular curb ramps shall comply with R303.2.1 and R303.3; parallel curb ramps shall comply with R303.2.2 and R303.3; blended transitions shall comply with R303.2.3 and R303.3.

Advisory R303.2 Types. This provision permits a combination of ramps and blended transitions.

It will sometimes be necessary to limit the run of a parallel or perpendicular ramp in order to avoid 'chasing grade' indefinitely. In new construction at standard curb heights, required level landings can provide a datum for measuring most curb ramp slopes.

Limiting new ramps to an 8.3% slope on steep routes will result in a slight increase in grade on the balance of the route, but will facilitate street crossing and a timely and manageable ascent to the sidewalk, particularly important when crossing in traffic.

R303.2.1 Perpendicular Curb Ramps. Perpendicular curb ramps shall have a running slope that cuts through or is built up to the curb at right angles or meets the gutter grade break at right angles.

R303.2.1.1 Running Slope. The running slope shall be 5 percent minimum and 8.3 percent maximum but shall not require the ramp length to exceed 4.5 m (15.0 ft).

R303.2.1.2 Cross Slope. The cross slope at intersections shall be 2 percent maximum. The cross slope at midblock crossings shall be permitted to be warped to meet street or highway grade.

R303.2.1.3 Landing. A landing 1.2 m (4.0 ft) minimum by 1.2 m (4.0 ft) minimum shall be provided at the top of the curb ramp and shall be permitted to overlap other landings and clear space. Running and cross slopes at intersections shall be 2 percent maximum. Running and cross slope at midblock crossings shall be permitted to be warped to meet street or highway grade.

R303.2.1.4 Flares. Flared sides with a slope of 10 percent maximum, measured parallel to the curb line, shall be provided where a pedestrian circulation path crosses the curb ramp.

Advisory R303.2.1.4 Flares. Sides of ramps may be returned, providing useful directional cues, if protected from cross travel by landscaping, street furniture, poles, or equipment.

R303.2.2 Parallel Curb Ramps. Parallel curb ramps shall comply with R303.2.2, and shall have a running slope that is in-line with the direction of sidewalk travel.

R303.2.2.1 Running Slope. The running slope shall be 5 percent minimum and 8.3 percent maximum but shall not require the ramp length to exceed 4.5 m (15.0 ft).

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R303.2.2.2 Cross Slope. The cross slope shall be 2 percent maximum.

R303.2.2.3 Landing. A landing 1.2 m (4.0 ft) minimum by 1.2 m (4.0 ft) minimum shall be provided at the bottom of the ramp run and shall be permitted to overlap other landings and clear floor or ground space. Running slope and cross slopes at intersections shall be 2 percent maximum. Running and cross slope at midblock crossings shall be permitted to be warped to meet street or highway grade.

R303.2.2.4 Diverging Sidewalks. Where a parallel curb ramp does not occupy the entire width of a sidewalk, drop-offs at diverging segments shall be protected.

R303.2.3 Blended Transitions. Blended transitions shall comply with R303.3. Running slope shall be 5 percent maximum and cross slope shall be 2 percent maximum.

R303.3 Common Elements. Curb ramps and blended transitions shall comply with R303.3.

R303.3.1 Width. The clear width of landings, blended transitions, and curb ramps, excluding flares, shall be 1.2 m (4.0 ft) minimum.

R303.3.2 Detectable Warnings. Detectable warning surfaces complying with R304 shall be provided, where a curb ramp, landing, or blended transition connects to a street.

R303.3.3 Surfaces. Surfaces of curb ramps, blended transitions, and landings shall comply with R301. Gratings, access covers, and other appurtenances shall not be located on curb ramps, landings, blended transitions, and gutters within the pedestrian access route.

R303.3.4 Grade Breaks. Grade breaks at the top and bottom of perpendicular curb ramps shall be perpendicular to the direction of ramp run. At least one end of the bottom grade break shall be at the back of curb. Grade breaks shall not be permitted on the surface of curb ramps, blended transitions, landings, and gutter areas within the pedestrian access route. Surface slopes that meet at grade breaks shall be flush.

R303.3.5 Counter Slopes. The counter slope of the gutter or street at the foot of a curb ramp, landing, or blended transition shall be 5 percent maximum.

R303.3.6 Clear Space. Beyond the curb face, a clear space of 1.2 m (4.0 ft) minimum by 1.2 m (4.0 ft) minimum shall be provided within the width of the crosswalk and wholly outside the parallel vehicle travel lane.

R304 Detectable Warning Surfaces

R304.1 General. Detectable warnings shall consist of a surface of truncated domes aligned in a square or radial grid pattern and shall comply with R304.

R304.1.1 Dome Size. Truncated domes in a detectable warning surface shall have a base diameter of 23 mm (0.9 in) minimum to 36 mm (1.4 in) maximum, a top diameter of 50 percent of the base diameter minimum to 65 percent of the base diameter maximum, and a height of 5 mm (0.2 in).

Advisory R304.1.1 Dome Size. Where domes are arrayed radially, they may differ in diameter within the ranges specified.

R304.1.2 Dome Spacing. Truncated domes in a detectable warning surface shall have a center-to-center spacing of 41 mm (1.6 in) minimum and 61 mm (2.4 in) maximum, and a base-to-base spacing of 17 mm (0.65 in) minimum, measured between the most adjacent domes.

Advisory R304.1.2 Dome Spacing. Where domes are arrayed radially, they may differ in center-to-center spacing within the range specified.

R304.1.3 Contrast. Detectable warning surfaces shall contrast visually with adjacent gutter, street or highway, or walkway surface, either light-on-dark or dark-on-light.

Advisory R304.1.3 Contrast. Contrast may be provided on the full ramp surface but should not extend to the flared sides. Many pedestrians use the visual contrast at the toe of the ramp to locate the curb ramp opening from the other side of the street.

R304.1.4 Size. Detectable warning surfaces shall extend 610 mm (24 in) minimum in the direction of travel and the full width of the curb ramp (exclusive of flares), the landing, or the blended transition.

R304.2 Location and Alignment.

R304.2.1 Perpendicular Curb Ramps. Where both ends of the bottom grade break complying with R303.3.4 are 1.5 m (5.0 ft) or less from the back of curb, the detectable warning shall be located on the ramp surface at the bottom grade break. Where either end of the bottom grade break is more than 1.5 m (5.0 ft) from the back of curb, the detectable warning shall be located on the lower landing.

Advisory R304.2.1 Perpendicular Curb Ramps. Detectable warnings are intended to provide a tactile equivalent underfoot of the visible curbline; those placed too far from the street edge because of a large curb radius may compromise effective crossing analysis.

R304.2.2 Landings and Blended Transitions. The detectable warning shall be located on the landing or blended transition at the back of curb.

R304.2.3 Alignment. The rows of truncated domes in a detectable warning surface shall be aligned to be perpendicular or radial to the grade break between the ramp, landing, or blended transition and the street.

Advisory R304.2.3 Alignment. Where a ramp, landing, or blended transition provides access to the street continuously around a corner, the vertical rows of truncated domes in a detectable warning surface should be aligned to be perpendicular or radial to the grade break between the ramp and the street for a 1.2 meter-wide (4.0 ft) width for each crosswalk served.

R304.2.3 Rail Crossings. The detectable warning surface shall be located so that the edge nearest the rail crossing is 1.8 m (6 ft) minimum and 4.6 m (15 ft) maximum from the centerline of the nearest rail. The rows of truncated domes in a detectable warning surface shall be aligned to be parallel with the direction of wheelchair travel.

R305 Pedestrian Crossings

R305.1 General. Pedestrian crossings shall comply with R305.

R305.2 Crosswalks. Crosswalks shall comply with R305.2 and shall contain a pedestrian access route that connects to departure and arrival walkways through any median or pedestrian refuge island.

R305.2.1 Width. Marked crosswalks shall be 1.8 m (6 ft) wide minimum.

R305.2.2 Cross Slope.

R305.2.2.1 Crossings with Stop Control. The cross slope shall be 2 percent maximum.

R305.2.2.2 Crossings without Stop Control. The cross slope shall be 5 percent maximum.

R305. 2.2.3 Midblock Crossings. The cross slope at midblock crossings shall be permitted to be warped to meet street or highway grade.

R305.2.3 Running Slope. The running slope shall be 5 percent maximum, measured parallel to the direction of pedestrian travel in the crosswalk.

R305.3 Pedestrian Signal Phase Timing. All pedestrian signal phase timing shall be calculated using a pedestrian walk speed of 1.1 m/s (3.5 ft/s) maximum. The crosswalk distance used in calculating pedestrian signal phase timing shall include the entire length of the crosswalk.

R305.4 Medians and Pedestrian Refuge Islands. Medians and pedestrian refuge islands in crosswalks shall comply with R305.4 and shall contain a pedestrian access route, including passing space, complying with R301 and connecting to each crosswalk.

R305.4.1 Length. Medians and pedestrian refuge islands shall be 1.8 m (6.0 ft) minimum in length in the direction of pedestrian travel.

Advisory R305.4.1 Length. The edges of cut-throughs and curb ramps are useful as cues to the direction of a crossing. This should be considered when planning an angled route through a median or island. Curb ramps in medians and islands can add difficulty to the crossing for some users. There are many factors to consider when deciding whether to ramp or cut-through a median or island. Those factors may include slope and cross slope of road, drainage, and width of median or island.

R305.4.2 Detectable Warnings. Medians and pedestrian refuge islands shall have detectable warnings complying with R304 at curb ramps and blended transitions. Detectable warnings at cut-through islands shall be located at the curbline in-line with the face of curb and shall be separated by a 61 cm (2.0 ft) minimum length of walkway without detectable warnings. Where the island has no curb, the detectable warning shall be located at the edge of roadway.

R305.5 Pedestrian Overpasses and Underpasses. Pedestrian overpasses and underpasses shall comply with R305.5.

R305.5.1 Pedestrian Access Route. Pedestrian overpasses and underpasses shall contain a pedestrian access route complying with R301.

R305.5.2 Approach. Where the approach slope exceeds 5 percent, the approach shall be a ramp 1.2 m (4.0 ft) minimum in width complying with R406 or an elevator, a limited use/limited application elevator, or platform lift complying with the applicable requirements in section 407, 408, and 410 of Appendix D to 36 CFR part 1191 (the ADA and ABA Accessibility Guidelines) and providing for independent operation.

Advisory R305.5.2 Approach. This provision leaves the decision of type of accessible vertical access up to the jurisdiction. Long ramps can present difficulties for some persons with disabilities and may require snow clearance. Elevators or lifts entail a maintenance obligation.

R305.5.3 Stairs. Stairs shall comply with R407.

R305.5.4 Escalators. Escalators shall comply with sections 6.1.3.5.6 and 6.1.3.6.5 of ASME A17.1 (incorporated by reference; see R104.2.3) and shall have a clear width of 82 cm (32 in) minimum.

R305.6 Roundabout Intersections. Where pedestrian facilities are provided at roundabout intersections, they shall comply with R305.6 and shall contain a pedestrian access route complying with R301.

R305.6.1 Separation. If walkways are curb-attached, there shall be a continuous and detectable edge treatment along the street side of the walkway wherever pedestrian crossing is not intended. Where chains, fencing, or railings are used, they shall have a bottom element 38 cm (15 in) maximum above the pedestrian access route.

Advisory R305.6.1 Separation. Because the pedestrian crossings are located off to the side of the pedestrian route around the street or highway and noise from continuously circulating traffic may mask useful audible cues. Carefully delineated crosswalk approaches with plantings, low enclosures, curbs, or other defined edges can be effective in identifying the crossing location(s). European and Australian roundabout intersections extend a 6- cm (24-inch) width of tactile surface treatment from the centerline of the ramp or blended transition across the full width of the sidewalk to provide an underfoot cue. Several manufacturers make a surface of raised bars for this use. The detectable warning surface should not be used, since it indicates the edge of a street or highway.

Schemes that remove cyclists from the circulating street or highway by means of a ramp that angles from the curb lane to the sidewalk and then provide re-entry by means of a similar ramp beyond the pedestrian crossing may provide false cues about the location of a crossing to pedestrians who are using the edge of the sidewalk for wayfinding. Designers should consider ways to mitigate this hazard.

R305.6.2 Signals. At roundabouts with multi-lane crossings, a pedestrian activated signal complying with R306 shall be provided for each segment of each crosswalk, including the splitter island. Signals shall clearly identify which crosswalk segment the signal serves.

Advisory R305.6.2 Signals. There are many suitable demand signals for this application. Crossings at some roundabout intersections in Australia and the United Kingdom

incorporate such systems, in which the driver first sees a flashing amber signal upon pedestrian activation and then a solid red while the pedestrian crosses to the splitter island (there is no green). These types of signals are also used in some U.S. cities at pedestrian crossings of arterial street or highways. The pedestrian pushbutton should be identifiable by a locator tone, and an accessible pedestrian signal incorporated to provide audible and vibrotactile notice of the gap created by the red signal. If properly signed, it need only be used occasionally by those who do not wish to rely solely on visual gap selection.

Roundabout intersections with single-lane approach and exit legs are not required to provide signals.

R305.7 Channelized Turn Lanes at Intersections. Where pedestrian crosswalks are provided at multi-lane right or left channelized turn lanes at intersections with pedestrian signal indications, a pedestrian activated signal complying with R306 shall be provided.

Advisory R305.7 Channelized Turn Lanes at Intersections. Accessible pedestrian signal devices installed at splitter and 'pork chop' islands must be carefully located and separated so that signal spillover does not give conflicting information about which crossing has the WALK indication displayed.

Additional guidance on signal types is provided in Advisory R305.6.2.

R306 Accessible Pedestrian Signals (APS)

R306.1 General. Pedestrian signals shall comply with R306.

R306.2 Pedestrian Signals. Each crosswalk with pedestrian signal indication shall have an accessible pedestrian signal which includes audible and vibrotactile indications of the WALK interval. Where a pedestrian pushbutton is provided, it shall be integrated into the accessible pedestrian signal and shall comply with R306.2.

Advisory R306.2 Pedestrian Signals. Signals should generally sound and vibrate throughout the WALK interval. Where signals rest in WALK, audible operation may be limited to a repetition at short intervals rather than continuous sounding for several minutes.

R306.2.1 Location. Accessible pedestrian signals shall be located so that the vibrotactile feature can be contacted from the level landing serving a curb ramp, if provided, or from a clear floor or ground space that is in line with the crosswalk line adjacent to the vehicle stop line.

R306.2.1.1 Crossings. Accessible pedestrian signal devices shall be 3.0 m (10.0 ft) minimum from other accessible pedestrian signals at a crossing. The control face of the accessible pedestrian signal shall be

installed to face the intersection and be parallel to the direction of the crosswalk it serves.

R306.2.1.2 Medians and Islands. Accessible pedestrian signals located in medians and islands shall be 1.5 m (5.0 ft) minimum from other accessible pedestrian signals.

R306.2.2 Reach and Clear Floor or Ground Space. Accessible pedestrian pushbuttons shall be located within a reach range complying with R404. A clear floor or ground space complying with R402 shall be provided at the pushbutton and shall connect to or overlap the pedestrian access route.

R306.2.3 Audible Walk Indication. The audible indication of the WALK interval shall be by tone or speech message.

R306.2.3.1 Tones. Tones shall consist of multiple frequencies with a dominant component at 880 Hz. The duration of the tone shall be 0.15 s and shall repeat at intervals of 0.15 s.

Advisory R306.2.3.1 Tones. Many new accessible pedestrian signal installations in the US use speech messages, which are perceived as being more user-friendly than tones. However, such messages may not be intelligible under high-ambient-noise conditions or to non-English speakers. Electronic tones are more universal and unambiguous. Section 4E.06 of the MUTCD specifies content of speech messages.

R306.2.3.2 Volume. Tone or voice volume measured at 92 cm (3.0 ft) from the pedestrian signal device shall be 2 dB minimum and 5 dB maximum above ambient noise level in standard operation and shall be responsive to ambient noise level changes.

Advisory R306.2.3.2 Volume. Where additional volume or beaconing features are available on pedestrian activation, they will momentarily exceed volume limits.

R306.3 Pedestrian Pushbuttons. Pedestrian pushbuttons shall comply with R306.3.

R306.3.1 Operation. Pedestrian pushbuttons shall comply with R405.4.

R306.3.2 Pushbutton Locator Tone. Pedestrian pushbuttons shall incorporate a locator tone at the pushbutton. Pushbutton locator tone volume measured at 92 cm (3.0 ft) from the pushbutton shall be 2 dB minimum and 5 dB maximum above ambient noise level and shall be responsive to ambient noise level changes. The duration of the locator tone shall be 0.15 s maximum and shall repeat at intervals of one second. The locator tone shall operate during the DON'T WALK and flashing DON'T WALK intervals only and shall be deactivated when the pedestrian signal is not operative.

R306.3.3 Size and Contrast. Pedestrian pushbuttons shall be a minimum of 0.5 cm (2 in) across in one dimension and shall contrast visually with their housing or mounting.

R306.3.4 Optional Features. An extended button press shall be permitted to activate additional features. Buttons that provide additional features shall be marked with three braille dots forming an equilateral triangle in the center of the pushbutton.

R306.4 Directional Information and Signs. Pedestrian signal devices shall provide tactile and visual signs complying with 306.4 on the face of the device or its housing or mounting to indicate crosswalk direction and the name of the street containing the crosswalk served by the pedestrian signal.

R306.4.1 Arrow. Signs shall include a tactile arrow aligned parallel to the crosswalk direction. The arrow shall be raised 0.8 mm (.03 inch) minimum and shall be 4 mm (1.5 in) minimum in length. The arrowhead shall be open at 45 degrees to the shaft and shall be 33 percent of the length of the shaft. Stroke width shall be 10 percent minimum and 15 percent maximum of arrow length. The arrow shall contrast with the background.

R306.4.2 Street Name. Accessible pedestrian signals (APS) shall include street name information aligned parallel to the crosswalk direction and shall comply with R409.3 or shall provide street name information in audible format.

R306.4.3 Crosswalk Configuration. Where provided, graphic indication of crosswalk configuration shall be tactile.

R307 Street Furniture

R307.1 General. Street furniture shall comply with R307.

Advisory R307.1 General. Elements are often placed on a sidewalk without coordination by different agencies or entities. Covered entities must ensure that the usability of the pedestrian access route is maintained.

Where items are added to an existing developed streetscape and the pedestrian walkway is not being replaced or altered within the scope of the project, locations should be carefully selected for minimum slope and cross slope and adequate width and maneuvering space to optimize usability.

R307.2 Clear Floor or Ground Space. Street furniture shall have clear space complying with R402 and shall be connected to the pedestrian access route.

MINNESOTA DEPARTMENT OF TRANSPORTATION
Engineering Services Division
Technical Memorandum No. 10-02-TR-01
February 11, 2010

To: Distribution 57, 612, 618, and 650

From: Khani Sahebjam, P.E.
Deputy Commissioner / Chief Engineer

Subject: Public Rights-of -Way Accessibility Guidance

Expiration
This Technical Memorandum supersedes Technical Memorandum 08-13-TS-05, and shall continue in force until February 11, 2015 unless superseded or suspended.

Implementation
The guidance contained in this Technical Memorandum is effective immediately. This Technical Memorandum affect projects in the design and construction phase and all work in Mn/DOT rights-of-way, including work done under permit or by agreement by other agencies or private entities.

These guidelines must be incorporated into all new construction, reconstruction, and alteration projects.

Projects that may directly or indirectly affect a qualified Historic Facility or District must be reviewed by the Cultural Resources Unit to determine if the proposed alteration may threaten or destroy the historic significance of the property. (See additional guidance under Guidelines)

A public agency is only exempt from fully meeting the Americans with Disabilities Act (ADA) standard where physical terrain or site conditions restrict the construction or altering the facility to the required standard. In such circumstances, the Design Project Manager must provide accommodation to the maximum extent feasible, document the instance with a memo signed by a direct supervisor, and place the documentation in the project file for reference and added to Mn/DOT's Transition Plan.

Accessibility improvements are to be planned, designed, and constructed to proceed at the same time as project roadway improvements. An addendum or supplemental agreement may be necessary for projects currently under construction.

If a Mn/DOT District Engineer determines that incorporating a new or updated accessible feature (or features) into a construction project will cause significant letting delays, the District Engineer (or designee) will direct the Resident Construction Engineer to issue a supplementary agreement to remedy the installation of the feature.

Local Road authorities are encouraged to adopt these or similar guidelines.

Introduction
Pedestrian facilities on public rights-of-way are required to be accessible to persons with disabilities through the following federal statutes:

- Section 504 of the Rehabilitation Act of 1973 (Section 504) (29 U.S.C. 5794) and
- Title II of the Americans with Disabilities Act of 1990 (ADA) (42 U.S.C. 59 12131-12164)

Title II of the ADA governs all state and local governments and their agencies and facilities, regardless of the funding source. All pedestrian facilities within the public rights-of-way designed, constructed, and/or altered on behalf of or for the use of a public entity must be readily accessible to and usable by persons

-MORE-

with disabilities. Mn/DOT's Strategic Plan and the Statewide Transportation Plan recognize accessibility as an integral part of the State's transportation networks.

Purpose
This Technical Memorandum sets forth interim planning and design guidance for accessible pedestrian facilities through the implementation of the Access Board's Draft Public Rights of Way Accessibility Guidelines (PROWAG) 2005. This implementation of PROWAG does not include the provisions for multilane roundabouts which are being analyzed by a separate roundabout committee.

The full text of PROWAG can be found at: http://www.access-board.gov/prowac/draft.pdf. A separate mailing of PROWAG will not be made.

Guidelines

Scoping
Project Managers are required to identify all accessible pedestrian facility needs in the scoping phase of project development for all new construction, reconstruction, and alteration projects.

New construction and reconstruction
All pedestrian facilities in new construction and reconstruction roadway projects are required to meet the accessibility guidance in PROWAG. All newly constructed and reconstructed standalone pedestrian facilities {e.g. trails, sidewalks, and sidewalk segments} located in the public right-of-way are required to meet the design guidance in PROWAG.

Alteration Projects
All alteration projects must, at a minimum, address all curb ramps in the curb radius by providing ramps where they are required and do not currently exist and to bring existing curb ramps into compliance with detectable warnings, cross slope, running slope, and landings. Curb ramp improvements must comply to the maximum extent feasible without regard to cost.

In an alteration project the scope of the initiating project determines which additional accessible features are included in the project and the extent to which additional accessible features must be addressed. Where pre-existing site conditions would require expanding the project's scope to purchase of right-of-way, relocate utilities, provide drainage work, etc. there is no expectation that the scope of work be expanded to provide the accessible feature. Pre-existing conditions include, but are not limited to, underlying terrain, right-of-way availability, underground structures, adjacent developed facilities, drainage, or the presence of a notable natural or historic feature. When other pedestrian facilities are within the right-of-way but are not part of the scope of the alteration project it is not required that work be done on those features. Any accessible feature that is not built to PROWAG standard must be documented with a memo signed by a direct supervisor, and placed in the project file and added to Mn/DOT's Transition Plan.

When developing the scope for an alteration project, project managers are encouraged to look at the total function and accessibility of the pedestrian network, including transit facilities such as bus stops and shelters. Project Managers are encouraged to identify and correct any accessibility barriers within the project limits to the maximum extent feasible, not just curb ramps. Addressing multiple elements or spaces within a facility may provide a cost-effective opportunity to make the entire facility, or a significant portion of it, accessible. Jurisdictions should consult their Transition Plans to determine if related work has been identified as needed to achieve program accessibility in existing facilities at the same location.

Alteration projects include all types of resurfacing work. Only the work types identified in the preventative maintenance section that follows are excluded from providing ADA improvements.

-MORE-

Preventative maintenance projects
Pedestrian facility upgrades and accessibility improvements are not required on preventative maintenance projects where the primary purpose of the project is to maintain the existing roadway without increasing the structural capacity of the system.

Preventative Maintenance:

- Asphalt crack sealing
- Bituminous pavement seal coat
- Chip sealing
- Isolated concrete dowel-bar retrofit
- Concrete repair: Isolated, partial and/or full-depth repairs to restore functionality of the slab; e.g., edge spalls, corner breaks
- Concrete joint sealing
- Concrete pavement surface planing/diamond grinding
- Slurry or micro-surfacing
- Bridge substructure preservation: concrete and steel
- Bridge superstructure activities: Painting, joint replacement, bearing rehabilitation/replacement and barrier/guardrail/railing restoration.

Preventative maintenance projects are typically applied to pavements in good condition with significant remaining service life. These activities include actions that are intended to retard future deterioration and maintain the functional condition of the roadway without increasing structural capacity. In general, these improvements do not appreciably affect the roadway or pedestrian access route surface. A pedestrian access route is defined as: a continuous and unobstructed walkway within a pedestrian circulation route specifically designed for ADA –accessible travel.

Historical Properties
All new construction, reconstruction, and alterations that may directly or indirectly affect a qualified Historic Facility or District must be reviewed by the Cultural Resources Unit to determine if the proposed alteration may threaten or destroy the historic significance of the property. The Cultural Resources Unit, OES, will make a determination of impact and recommend accessible feature location and design solutions that will preserve the historic significance of the property.

Accessibility during construction
When a pedestrian access route is disrupted, closed, or relocated during construction, maintenance work, or other temporary condition, the alternative pedestrian access route shall include pedestrian ramps to maintain accessibility. See the Minnesota Manual on Uniform Traffic Control Devices (MN MUTCD) for further guidance on the requirements for establishing an alternative pedestrian access route for temporary traffic control. See also the "Pedestrian Accessibility Considerations in Temporary Traffic Control Zones Check List" in the MN MUTCD.

Questions
For information on the technical contents of this memorandum, please contact **Kristie Billiar, ADA Implementation Coordinator, at (651) 366-3174.**

Any questions regarding publication of this Technical Memorandum should be referred to the Design Standards Unit, designstandards.dot@state.mn.us. A link to all active and historical Technical Memoranda can be found at http://techmemos.dot.state.mn.us/techmemo.aspx.

To add, remove, or change your name and/or address on the Technical Memoranda mailing list, write or call the Mn/DOT Central Office Mail Room G-18, Transportation Building, 395 John Ireland Blvd., St. Paul, MN 55155, phone number (651) 366-3051.

-END-

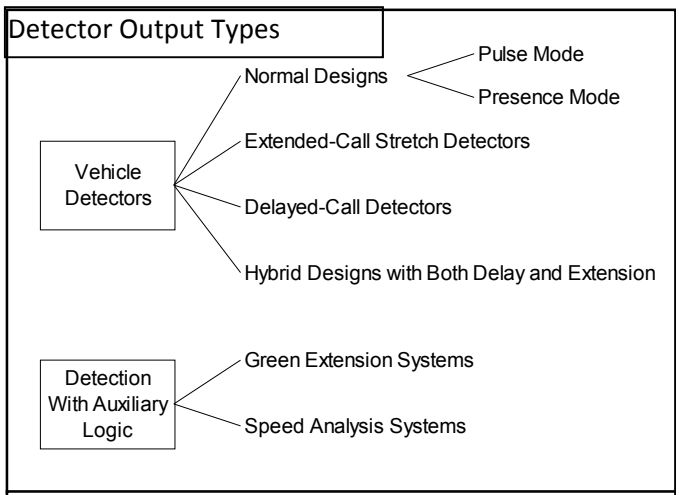
4.4 VEHICLE DETECTION TYPES

The different types of vehicle detectors available include but are not limited to the following types:

- **Magnetic/Magnetometer** detects moving ferrous metal objects – pulse.
- **Photo electric/Infrared** detects a break in a beam of light – presence or pulse.
- **Radar/Microwave** detects moving objects by sending and receiving electronic pulses – pulse.
- **Ultrasonic** detects sound with a microphone – presence or pulse.
- **Inductive loop** detects a change in resonant frequency by the introduction of a ferrous metal in the magnetic field of the detection zone.
- **Video** detects a change in a video pixel range – presence or pulse.
- **Microloop** detects a change by moving ferrous metal in the earth's magnetic field – pulse.

4.5 TYPES OF VEHICLE DETECTION

The Figure at the right is a classification of types of detection for traffic actuated controllers.



Traffic Actuated Control Detection

Some detectors record vehicles whether stopped or in motion. Others require that the vehicle be moving at a speed of at least 2 or 3 mph.

1. Normal loop or magnetic detectors will operate in either the pulse mode or presence mode. The magnetic detector produces a short output pulse when detection occurs, no matter how long the vehicle remains in the detection area. The normal loop is intended to produce a detector output for as long as a vehicle is in the field of detection.
2. An extended-call detector has a "carryover output", meaning that it holds or stretches the call of a vehicle for a period of seconds that has been set on an adjustable timer incorporated into the controller or detector.
3. A delayed-call detector does not issue an output until the detection zone has been occupied for a period of seconds that has been set on an adjustable timer incorporated into the controller or detector. Hybrid detector designs incorporating both delay and extension are now relatively common.

Current industry standard traffic signal controllers extend the capabilities of the normal detector/controller hardware. This controller functionality employs auxiliary timers and monitors circuits. This functionality allows the enabling and disabling of selected detectors, control of the yield of green, and the activation of "Hold-in Phase" circuits in order to supplement controller timing.

1. Examples of controller functionality are; locking memory, non-lock, delay call, extend (stretch) call, and stop bar.
2. Another type of detection is the "speed analysis system". This system is a hardware assembly composed of two loop detectors and auxiliary logic. The two loops are installed in the same lane a

precise distance apart. A vehicle passing over the loops produces two actuations. The time interval between the first and the second actuation is measured to determine vehicle speed.

4.5.1 Inductive Loop Detectors

The most common type of vehicle detection device in use today is the inductive loop. This is a loop of wire imbedded in the pavement (saw cut in existing concrete or Rigid PVC loop in new concrete) carrying a small electrical current. When a large mass of ferrous metal passes over the loop, the magnetic field is disturbed and generates, or induces, a change in resonant frequency in the wire. This change in frequency is then recognized by the detector amplifier and signals the controller that a vehicle is present.

4.5.2 Microwave Radar Detectors

Development of microwave radar during World War II enabled this technology to be applied to detection of vehicular traffic. The principles of operation involve microwave energy being beamed on an area of roadway from an overhead antenna, and the vehicle's effect on the energy detected. The antennas capture a portion of the transmitted energy reflected toward them by objects in the field of view. By direct comparison of transmitted energy with reflected energy from a moving vehicle, a Doppler beat note can be detected which in turn can be used to operate an output device. Use of continuous wave (CW) transmission and reliance on the use of a Doppler signal from the return wave eliminates the need for any gating or distance measurement, and, thereby, provides a simple detector responsive to vehicles **moving** through the field. By appropriate processing of information in the received energy, direct measurements of vehicle presence, occupancy, and speed can be obtained.

4.5.3 Video image processing

Vehicle detection by video cameras is one of the most promising new technologies for non-intrusive large-scale data collection and implementation of advanced traffic control and management schemes. This concept provides real-time vehicle detection and traffic parameter extraction from images generated by video cameras. Major worldwide efforts have been directed at development of a practical device for image processing. Under FHWA sponsorship, a wide-area, multi-spot Video Imaging Detector System (VIDS) was developed at the University of Minnesota and is commercially available.

A video image processing system typically consists of the following components:

- Image hardware - The imaging sensor is an electronic camera (conventional TV camera or an infrared camera) that overlooks a section of the roadway and provides the desired image information.
- Processor - A processor determines vehicle presence or passage from images received by the camera. It also provides other traffic parameters preferably in real-time.
- Software - Advanced tracking system software performs operations, detector programming, viewing of vehicle detections, and roadway surveillance.

Image processing detection systems can detect traffic in many locations (i.e., multiple spots) within the camera's field of view. These locations can be specified by the user in minutes using interactive graphics, and can be changed as often as desired. This flexible detection is achieved by placing detection lines along or across roadway lanes on a TV monitor displaying the traffic scene (not physically placed in the pavement). Each time a vehicle image crosses these lines, a detection signal (presence or passage) is generated. The result is similar to that produced by loop detectors.

VIDS are advantageous in traffic detection since:

- They are mounted above the road rather than in the road, providing multi-lane coverage along with installation and servicing advantages of traffic flow maintenance and personnel safety during detector repair.
- Placement of vehicle detection zones on the road is not limited to a particular detection configuration. The configuration can be controlled and adjusted manually (by an operator with a computer terminal) or dynamically (by software) at any time, as a function of traffic flow.
- The shape of the detection zone can be programmed for specific applications, such as freeway incident detection, detection of queue lengths (that cannot easily or economically be derived by conventional devices) and detection of turning patterns on city arterials.

Video detection design is not covered in this class. Work with the vendor on the proper design of video detection.

4.6 MNDOT VEHICLE DETECTION PRACTICES

4.6.1 Definition of Terms

CALL	A registration of a demand for the right-of-way by traffic at a controller unit.
CHECK	An outgoing circuit of the controller unit that indicates the existence of an unanswered call.
DETECTOR	A device for indicating the presence or passage of vehicles.
ACTUATION	The operative response of any type of detector.
DETECTOR	The retention of an actuation for the future utilization by the controller unit.
NON-LOCKING	A mode of actuated-controller-unit operation which does not require detector memory.

Depending on the controller type, the function may or may not be used.

4.6.2 Loop Detector Placement Design

1. **Guaranteed Green.** By detector design and functioning, all vehicles except right turn on red (RTOR) vehicles will be guaranteed service of a green light within a cycle. A positive call will be placed to the controller in advance of the stop line to give service to 100% of the vehicles that need a green. If right turns can be segregated from thru and right turn movements, a lock operation can be used with special detector functioning to guarantee a green. If right turn segregation is not possible, and a non-lock operation must be used, ample front detection must be provided to assure all vehicles are given a green at variable stopping locations.
2. **Safety.** Consideration must be given to winter as well as summer conditions. Advanced detection (passage) must be provided at all posted speeds at or above 35 mph (55 km/hr). Advanced detection will greatly reduce : 1. Vehicles skidding into the intersection, 2. rear end accidents, 3. right angle accidents, 4. delay. Detection that doesn't guarantee required greens will cause drivers to take chances and have accidents.
3. **Failsafe**. Alternatives must be provided for when a primary detector fails so that non mainline phases do not have to be placed on recall. Typically an advanced (passage) detector will become the primary detector when a stop bar detector fails and the phase is placed in the lock mode. In other situations detector delay times can be removed. With left turn detectors, faulty detectors can be unspliced from multiple detectors. Fixed time recalls should be avoided.
4. **Maintenance**. Detectors should be located in a good roadbed, if the surface is in a very poor condition it should be replaced. Multiple "Home Runs" (loop lead ins) should be avoided when crossing multiple lanes, as it will cause pavement failure and possibly crosstalk. Conduits should be installed to eliminate long home runs when possible. Consideration should be given to installing non-intrusive detectors to reduce maintenance complexity.”
5. **Operation.** Detectors should provide operation that is logical to the driving public. Drivers should not feel that they were "cut off ", overly delayed, or have to make quick decisions. The average driver in the United States spends six months of his or her life waiting at traffic signals.

4.6.3 Loop Detector Cable Lead-ins

A typical MnDOT signal controller cabinet detector rack will have space for 32 detectors (6 - four channel detector cards), two EVP cards (2- two channel) and a one 4 channel or 2 two channel Pedestrian Isolator cards. The new cabinets will support 8 - 4 channel or 16 - 2 channel detectors. Adding EVP does not reduce the number of loop detector channels.

4.7 VEHICLE DETECTOR EXHIBITS

The exhibits on the following pages (**4-26** to **4-35**) are typical detector layouts for a variety of situations. They are arranged as shown below.

Exhibit	Page	Comments
Exhibit 4-1 Detector Placement Chart – Decision Zones	4-26	Shows the placement of a detector considering vehicle decision zones.
Exhibit 4-2 Major Approach	4-27	These are developed based on the decision zones. Chart includes an optional mid-point detector.
Exhibit 4-3 Minor Approach with Right Turn Lane (RTOR Allowed)	4-28	Typical minor street arrangement with permissive only left turn movements.
Exhibit 4-4 Minor Approach Protected / Permissive Left - 1 Through Lane	4-29	Minor street arrangement with a protected / permissive operation (or FYA) and 1 through lane.
Exhibit 4-5 Minor Approach Protected / Permissive Left - 2 Through Lanes	4-30	Minor street arrangement with a protected / permissive operation (or FYA) and 2 through lanes.
Exhibit 4-6 Protected Permissive and FYA Left Turn	4-31	Exclusive left turn lane, 4-loop configuration used for a protected / permissive left (includes a FYA).
Exhibit 4-7 Protected Left Turn - Lock Operation	4-32	Exclusive left turn lane with raised median, 2-loop configuration used for a protected left turn using lock mode.
Exhibit 4-8 Protected Left Turn - Non Lock Operation	4-33	Exclusive left turn lane with raised or painted median, 4-loop configuration
Exhibit 4-9 Minor Approach	4-34	Minor approach with no exclusive turn lanes. This configuration would not be typically used for a new intersection.
Exhibit 4-10 Leading Protected / Permissive Left Turn from a Through Lane	4-35	Approach with no exclusive turn lanes and a protected / permissive left turn operation. This configuration would not be typically used for a new intersection.

These charts are generally intended for new signals designs and <u>may not be feasible for a rebuild/modification</u>. If the design is a rebuild or modification, these charts can act as guidance, but engineering judgment should be applied.

Exhibit 4-1 Detector Placement Chart – Decision Zones

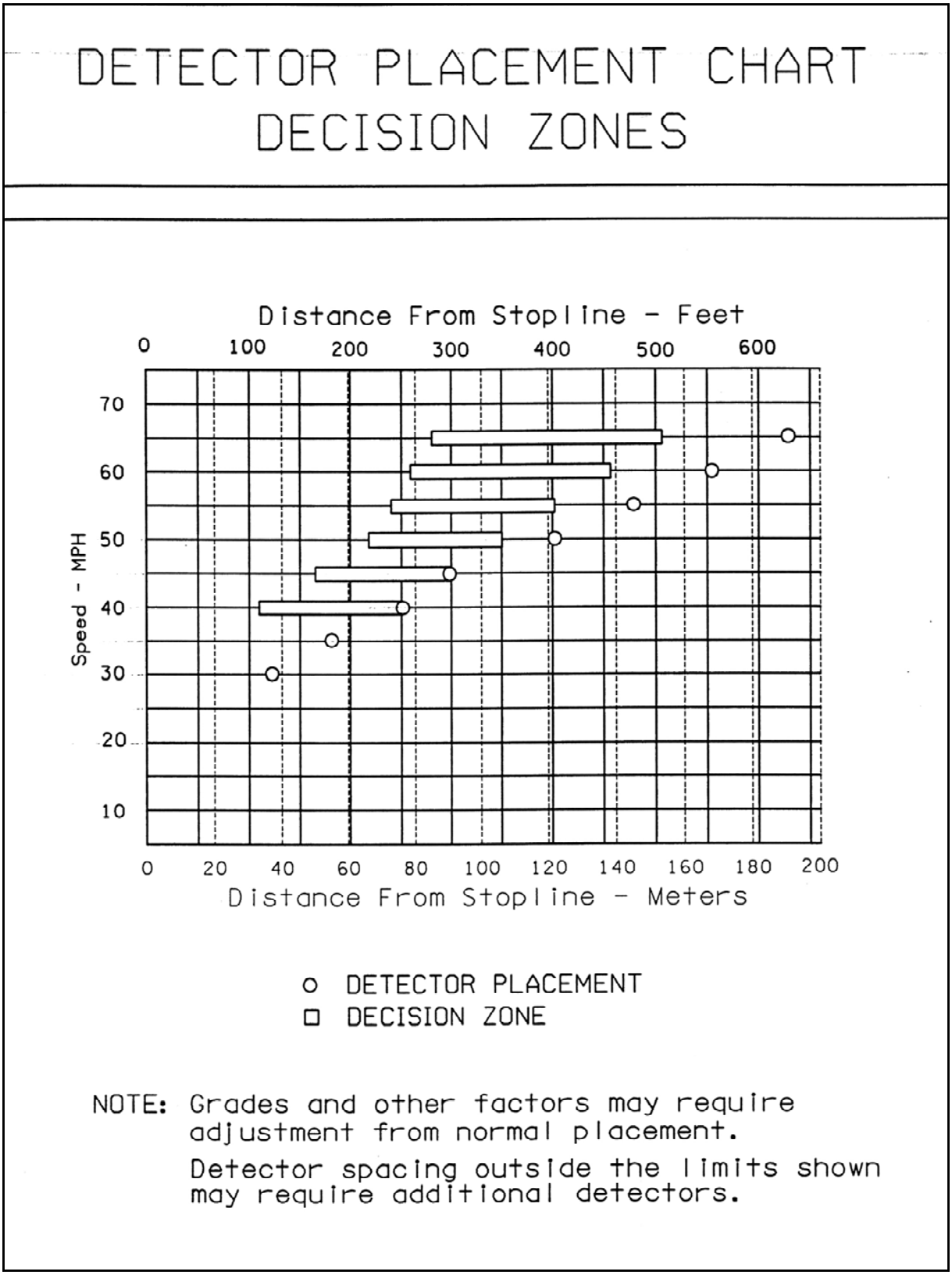
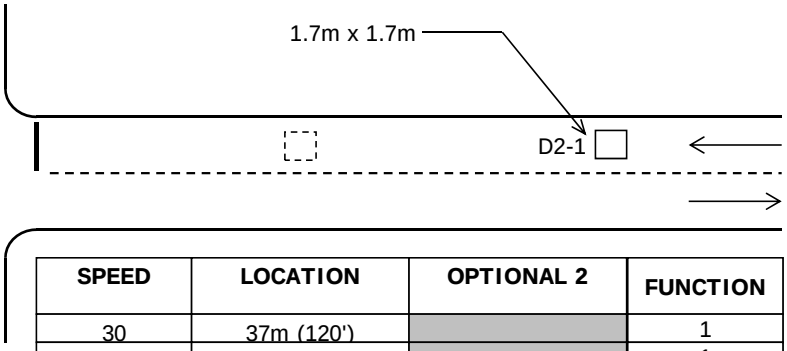


Exhibit 4-2 Major Approach

LOOP DETECTOR PLACEMENT

MAJOR APPROACH



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

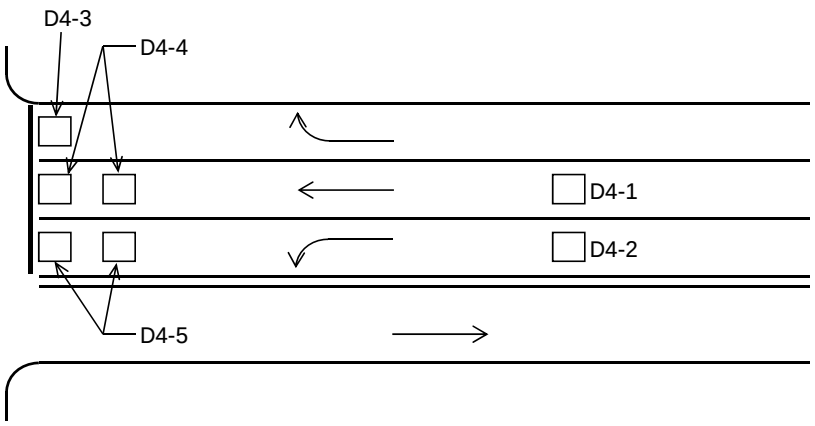
FIGURE 1

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

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

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

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.

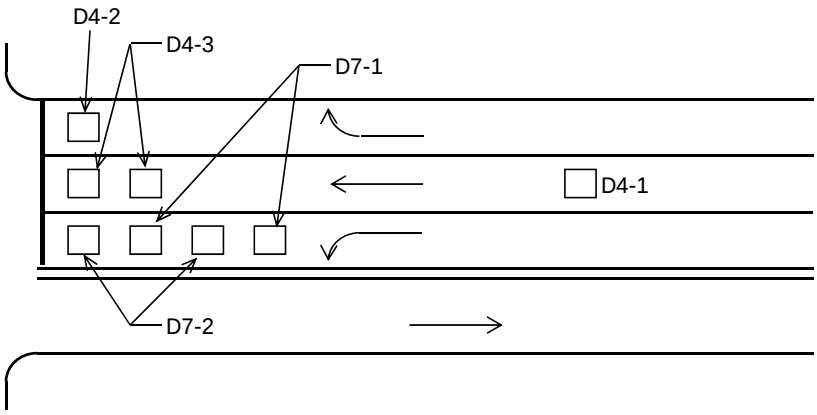
FIGURE 2

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	D4-1
30	37m (120')
35	55m (180')
40	76m (250')

NUMBER	FUNCTIO	SIZE	LOCATION
D4-1	1	1.7 x 1.7m (6' X 6')	SEE LEFT
D4-2	7	1.7 x 1.7m (6' X 6')	1.5m (5')
D4-3	1	2 - 1.7 x 1.7m (6' X 6')	1.5 & 6m (5' & 20')
D7-1	1	2 - 1.7 x 1.7m (6' X 6')	6m (20') & 15m (50')
D7-2	1	2 - 1.7 x 1.7m (6' X 6')	1.5m (5') & 11m (35')

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.

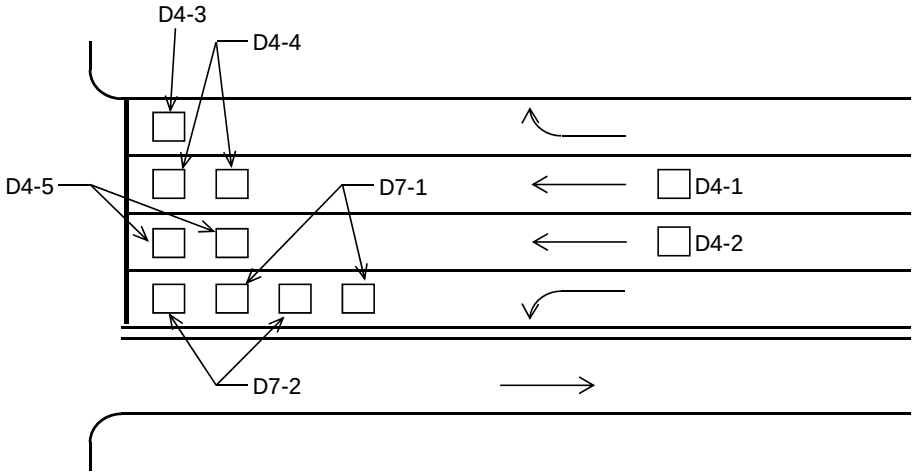
FIGURE 3

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	D4-1
30	37m (120')
35	55m (180')
40	76m (250')

NUMBER	FUNCTIO	SIZE	LOCATION
D4-1	1	1.7 x 1.7m (6' X 6')	SEE LEFT
D4-2	1	1.7 x 1.7m (6' X 6')	SEE LEFT
D4-3	7	1.7 x 1.7m (6' X 6')	1.5m (5')
D4-4	1	2 - 1.7 x 1.7m (6' X 6')	1.5 & 6m (5' & 20')
D4-5	1	2 - 1.7 x 1.7m (6' X 6')	1.5 & 6m (5' & 20')
D7-1	1	2 - 1.7 x 1.7m (6' X 6')	6m (20') & 15m (50')
D7-2	1	2 - 1.7 x 1.7m (6' X 6')	1.5m (5') & 11m (35')

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.

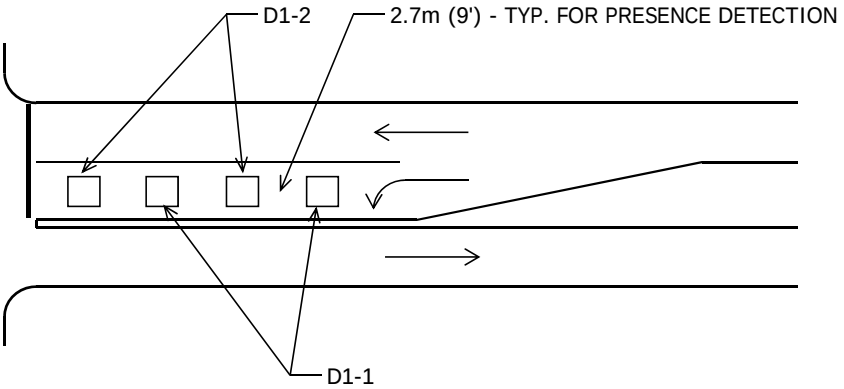
FIGURE 4

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
D1-1	1	2 - 1.7 x 1.7m (6' X 6')	6m (20') & 15m (50')
D1-2	1	2 - 1.7 x 1.7m (6' X 6')	1.5m (5') & 11m (35')

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).

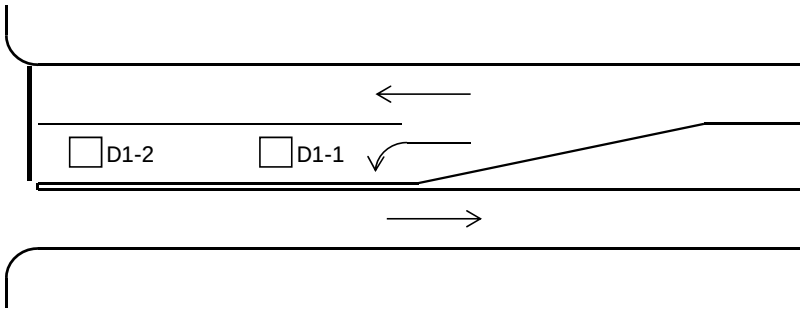
FIGURE 5

Exhibit 4-7 Protected Left Turn - Lock Operation – Raised Median

LOOP DETECTOR PLACEMENT

PROTECTED LEFT TURN

LOCK OPERATION - RAISED MEDIAN



LOCATION = DISTANCE FROM STOP BAR TO LOOP DETECTOR

FRONT LOOP	BACK LOOP
3m (10')	12m (40')

LOOP DETECTOR FUNCTIONS
1 = CALL AND EXTEND

NUMBER	FUNCTIO	SIZE
D1-1	1	1.7 x 1.7m (6' X 6')
D1-2	1	1.7 x 1.7m (6' X 6')

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.

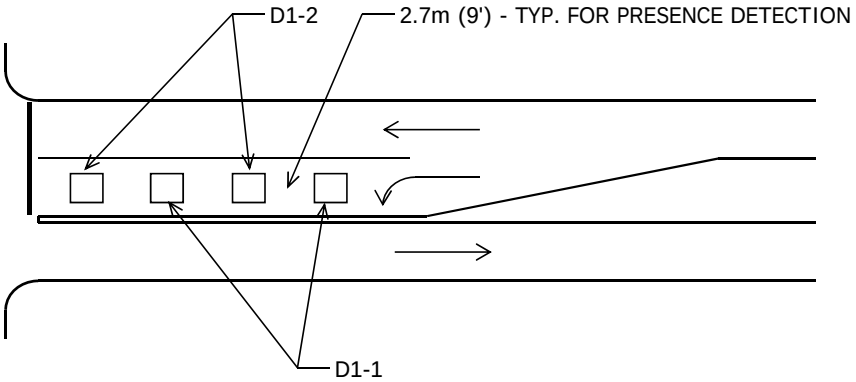
FIGURE 6

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	FUNCTIO	SIZE	LOCATION
D1-1	1	2 - 1.7 x 1.7m (6' X 6')	6m (20') & 15m (50')
D1-2	1	2 - 1.7 x 1.7m (6' X 6')	1.5m (5') & 11m (35')

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.

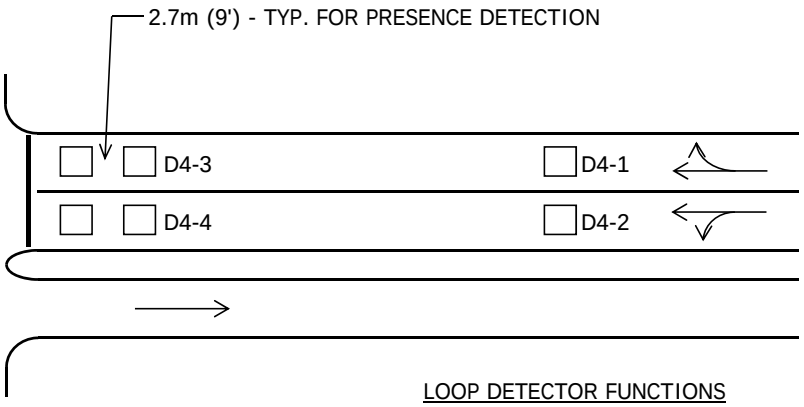
7) THE CONTROLLER PHASE AND DETECTION FUNCTIONS SHALL BE ON NON-LOCK WITH NO RECALL.

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	1.5 & 6m (5' & 20')	37m (120')
35	1.5 & 6m (5' & 20')	55m (180')
40	1.5 & 6m (5' & 20')	76m (250')
45	1.5 & 6m (5' & 20')	92m (300')
50	1.5 & 6m (5' & 20')	122m (400')
55	1.5 & 6m (5' & 20')	145m (475')

NUMBER	FUNCTION	SIZE
D4-1	3	1.7 x 1.7m (6' X 6')
D4-2	1	1.7 x 1.7m (6' X 6')
D4-3	7 OR 9	2 - 1.7 x 1.7m (6' X 6')
D4-4	1 OR 8	2 - 1.7 x 1.7m (6' X 6')

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

3) PROVIDE GOOD COVERAGE FOR FRONT DETECTION FOR VARIABLE STOPPING LOCATIONS. USE ANY COMBINATION OF 1.7m x 1.7m (6' x 6') OR 1.7m x 3m (6' x 10') LOOP DETECTORS.

4) IF USING NMC LOOP, MAY COMBINE DUAL LOOPS.

5) ADVANCED DETECTION IS OPTIONAL.

6) USED WITH PRESENCE DETECTION.

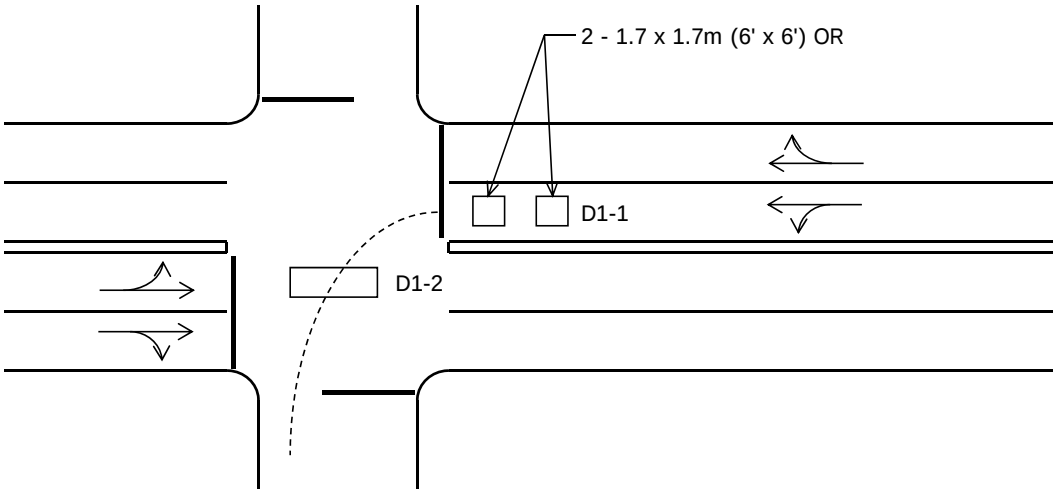
FIGURE 8

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	FUNCTIO	SIZE
D1-1	5	2 - 1.7 x 1.7m (6' X 6')
D1-2	3	1.7 x 6m (6' X 20')

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

4.8 DETECTOR FUNCTIONS

The information following this page is a handout taken from the Minnesota Department of Transportation Traffic Signal Timing and Coordination Manual. The most current version of the Traffic Signal Timing and Coordination Manual can be found at:

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

Note: It is recommended that you review all original reference material.

3.9 Detection

The section discusses the functions available for traffic signal detectors. The design and layout of detectors at an intersection is discussed in the Traffic Signal Design Manual. Refer to page 3-38 for information from the Signal Design Manual.

Detector Labeling and Phase Assignments

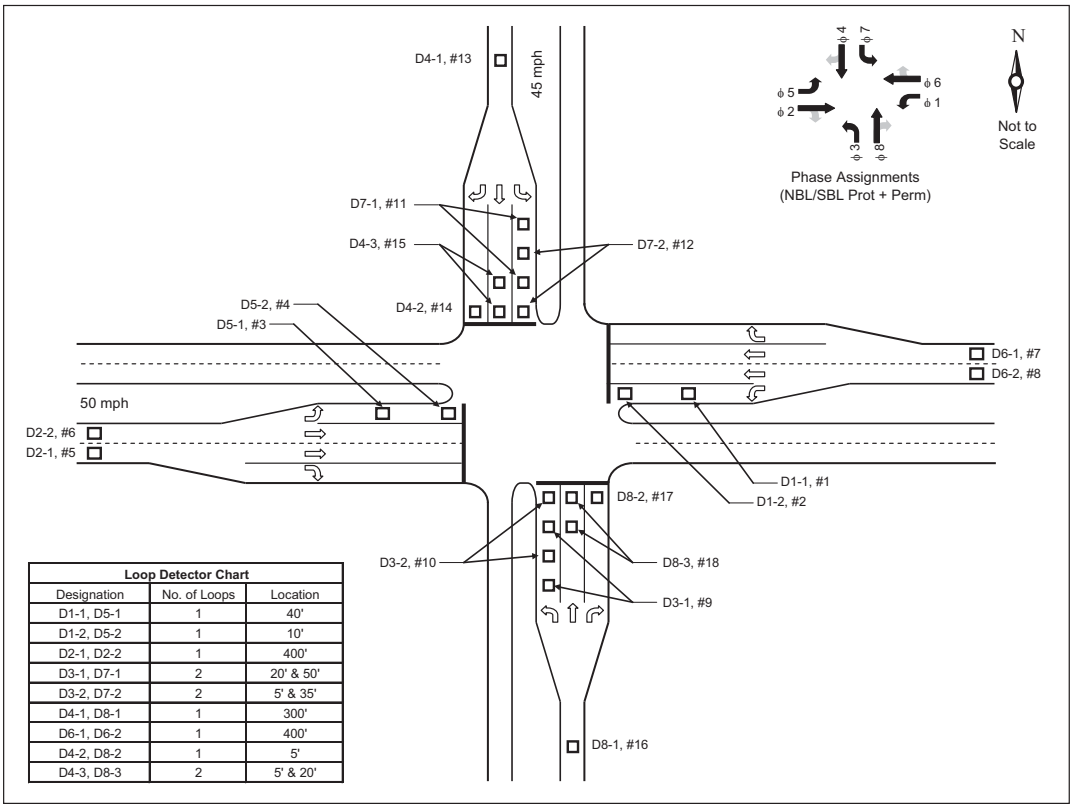
In loop detector design, detectors are labeled on the plan set according to the following rules:

Number detectors per phase 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. At the stop line, Number 3 would be in the right lane with Number 4 to the left as you proceed to the intersection. These numbers should be proceeded by a D and the controller phase number (an example D8-1, D8-2, etc.). Also, if there is more than one detector in the left lane, Number 1 would be the first detector as you approach the intersection and Number 2 the second.

For controller functions, detectors will have a single unique number from 1 to 32. Therefore, the detector will have two labels; one for the plan sheet (i.e. D1-1) and one for the controller functions (i.e. Detector #1).

Refer to the image below. At this intersection there are 8 phases. Each detector is labeled with the plan sheet label and local detector (LD) number. For instance, the northernmost detector is for phase 4 SBT. On the plan set, this is indicated as D4-1. For the LD Phase Assignment this is Detector #13.

Exhibit 3-14 Detector Labeling and Phase Assignment Diagram



Loop Detector Chart		
Designation	No. of Loops	Location
D1-1, D5-1	1	40'
D1-2, D5-2	1	10'
D2-1, D2-2	1	400'
D3-1, D7-1	2	20' & 50'
D3-2, D7-2	2	5' & 35'
D4-1, D8-1	1	300'
D6-1, D6-2	1	400'
D4-2, D8-2	1	5'
D4-3, D8-3	2	5' & 20'

Assigning TS2 Type 1 Detector Numbers

As noted above, the signal operator will label each detector with a unique number from 1 to 32. This is done by filling out the TS2 Type 1 Detector Phase Assignment list found at the following link:

www.dot.state.mn.us/trafficeng/signals/signalworksheets.html

The detector layout shown in the section above is used as an example to fill out the TS2 Type 1 Detector Phase Assignment below.

In this example, detector D4-1 and D8-1 are set at 300' and D4-3 and D8-3 are at 20' back from the stop bar (per Figure 2 of the Signal Design Manual). At 45 mph, a vehicle takes 4.23 seconds to travel 280' (the distance between the detectors). However, it is not desirable to have detector D4-3 and D8-3 extend the phase 4.23 seconds. So, the vehicle extension can be set to 1.0 seconds. Then, detector D4-1 and D8-1 can have a detector extend of 3.23 seconds. This will allow the phase to extend the full 4.23 seconds between detectors but only 1.0 second after leaving phase D4-3 and D8-3.

Exhibit 3-15 TS2 Type 1 Detector Phase Assignment Chart

TE# System I.D.# Date:

TS2 Type 1 Detector Phase Assignment

Intersection: TH 1 and Main St.

Rack 1 BIU Address 9

Zone	Local Detector	Detector #	*Type*	Phase 1	2	3	4	5	6	7	8	9	10	11	12	Extend	Delay
SA1	D1-1	1	0	x												0	0
	D1-2	2	0	x												0	0
	D5-1	3	0					x								0	0
	D5-2	4	0					x								0	0
SA2	D2-1	5	0		x											0	0
	D2-2	6	0		x											0	0
	D6-1	7	0						x							0	0
	D6-2	8	0						x							0	0
SA3	D3-1	9	0			x					x					0	0
	D3-2	10	0			x					x					0	0
	D7-1	11	0				x			x						0	0
	D7-2	12	0				x			x						0	15
SA4	D4-1	13	0				x									3.23	0
	D4-2	14	1				x									0	15
	D4-3	15	0				x									0	0
	D8-1	16	0								x					3.23	0

Rack 2 BIU Address 10

	Local Detector	Detector #	*Type*	Phase 1	2	3	4	5	6	7	8	9	10	11	12	Extend	Delay
SA1	D8-2	17	1								x					0	15
	D8-3	18	0								x					0	0
		19															
		20															
SA2		21															
		22															
		23															
		24															
SA3		25															
		26															
		27															
		28															
SA4		29															
		30															
		31															
		32															

***Types**
0 = Normal
1 = extend/delay
S = system

Note: Each rack is wired to support 4 additional channels of EVP or Pedestrian detection not shown above.

Detector assingments should be done in the following order:
1. All main line left turns
2. All main line thru lanes
3. All cross street left turns
4. All cross street thru lanes
5. All other detection (Overlaps, System Detectors)

3/20/2007

Common Detector Functions

Below is a list of the common by detector functions that can be used.

1. CALL & EXTEND — Upon actuation the detector immediately places a call on its associated phases at all times. The detector shall also immediately cause the controller to extend the green time for the actuating vehicle only during the green interval of that phase. The controller phase and the individual detector may be in Lock or Non-Lock mode.
2. DELAY CALL - IMMEDIATE EXTEND — When actuated during the yellow and red interval of its associated phase, the detector delays its output call for a pre-determined length of time during the extended presence actuation. After the time delay expires, the call remains active at the controller unit as long as the detector stays actuated. The detector shall also immediately cause the controller unit to extend the green time for the actuating vehicle only during the green interval of that phase. The controller phase and the individual detector may be in Lock or Non-Lock mode.
3. EXTEND ONLY — The detector immediately registers actuation at the Controller unit only during the green interval for that phase thus extending the green time before the actuating vehicles. The controller phase and the individual detector may be in Lock or Non-Lock mode.
4. SYSTEM — Any type of vehicle detector used to obtain representative traffic flow information.
5. CALL ONLY — Upon actuation the detector immediately places a call on its associated phase only during the red interval of that phase. This call remains active as long as the detector is actuated. The controller phase or individual detector may be in Lock or Non-Lock mode.
6. QUEUING — The detection of vehicles on one or more intersection approaches solely for the purpose of modifying the sequence and/or length of a phase.
7. CALL ONLY DENSITY — Upon actuation the detector immediately places a call on its associated phase only during the red interval of that phase. This call is inactivated when the controller unit outputs a check. This allows the use of density functions on this phase but necessitates the use of detector memory (lock) on the controller unit.
8. DELAY CALL DENSITY ONLY — When actuated during the red interval of its associated phase, the detector delays its output call for a pre-determined length of time during the extended actuation. This call is inactivated when the controller unit outputs a check and the time delay unit is not reset until after that phase has been served. This allows the use of density functions on this phase but necessitates the use of detector memory (lock).
9. CARRY-OVER CALL & EXTEND — Upon actuation the detector immediately places a call on its associated phase at all times and continues to output the call for a pre-determined length of time. The detector shall also immediately cause the controller unit to extend the green time for the actuating vehicle during the green interval of that phase and shall continue its output for a pre-determined length of time following an actuation. The controller unit may be in Lock or Non-Lock mode.

10. DELAY CALL ONLY — When actuated during the red interval of its associated phase, the detector delays its output call for a pre-determined length of time during the extended presence actuation. After the time delay expires, the call remains active at the controller unit as long as the detector remains actuated. The controller phase or individual detector may be in Lock or Non-Lock mode.

11. STOP BAR — Calls are accepted when the phase is not green and are held during green until the detector is empty, the detector is then disconnected. Additional Stop Bar functions are available where a timer can allow additional time before disconnect.

Summary of By Phase and By Detector Functions

As detailed throughout this manual, the signal operation has a variety of functions that can be applied by phase and/or by detector. The functions give the operator flexibility in controller the variable green time (the time between the minimum green and the maximum green).

The table below is a summary of some of the common functions available by phase and/or by detector. The list is not all inclusive of the functions available for each controller manufacturer.

Function	By Phase	By Detector	Definition
Minimum Green	X		Refer to page 3-12 and page 4-17
Passage, Vehicle Extension, Gap	X	X	Refer to page 3-12 and page 4-18
Maximum Green	X		Refer to page 3-12 and page 4-20
Volume Density Control (gap reduction, added initial, computed initial)	X		Refer to page 3-14 and page 4-17
Recall	X		Refer to page 3-13
Lock Call	X	X	Refer to page 3-15 and below
Delay Call		X	Refer to page 3-36
Stop Bar		X	Refer to page 3-36

Detector Modes

Detectors can be operated in a pulse or presence mode. In pulse Mode the detector produces a short output pulse when detection occurs. In presence Mode the detector output continues if any vehicle (first or last remaining) remains in the zone of detection.

Detectors can also be operate with a lock or non-lock feature. The lock feature means that a vehicle call is held by the controller (even after the vehicle has left the detection area) until the call has been satisfied. This type of detection memory is usually associated with point detection such as one 1.8 m X 1.8 m (6' X 6')

loop or a magnetometer. It has the advantage of minimizing detection costs, but is incapable of screening out false calls.

In the non-lock mode of memory, a waiting call is dropped by the controller as soon as the vehicle leaves the detection area. Non-lock detection memory is associated with large areas of detection at the stop line. This type of operation can reduce delay by screening out false calls, but has greater installation costs due to the large areas of detection needed.

Detection Design

The information following this page is a handout taken from the Minnesota Department of Transportation Signal Design Manual. The most current version of the Signal Design Manual can be found at:

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

It is recommended that you review all original reference material.

5. DESIGN CHECKLISTS

In this chapter, a number of signal design checklists are presented. Section **5.1** is Preliminary Signal Design Checklist – Field Investigation, Section **5.2** is the Source of Power Checklist and Section **5.3** is the Traffic Signal Plan Check List.

These checklists are also stored on the MnDOT OTST website. Please check frequently for updates to these checklists. The checklist is stored at:

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

5.1 PRELIMINARY SIGNAL DESIGN CHECKLIST – FIELD INVESTIGATION

INTERSECTION:		DATE/TIME	
S.P.:		FINAL DESIGN SQUAD	
FIELD REVIEWER:		CITY	
COUNTY:		POWER (name of company)	
UTILITIES (note what is in place):		RIGHT OF WAY/PROPERTY LINES:	
SPEED:		FUNDING	
	(TH) (CROSS ST.)	HOUSE MOVING ROUTE:	Y/N Y/N (TH) (CROSS ST.)

DRIVE THROUGH/FIELD WALK

- ❑ ALIGNMENT OF LANES
- ❑ SOP (SOURCE OF POWER), WHERE IS BEST PLACE FOR SOP
- ❑ OVERHEAD WIRES OR STRUCTURES
- ❑ PRESENCE AND CONDITION OF CURB AND GUTTER, ADD 4' X 4' FLAT AREA
- ❑ PEDESTRIAN RAMPS/PEDESTRIAN AMENITIES
- ❑ URBAN OR RURAL, PLAN FOR FUTURE
- ❑ ENTRANCES – SHOULD BE BEFORE ADVANCE DETECTION
- ❑ LIGHTING
- ❑ DRAINAGE FEATURES
- ❑ PARKING RESTRICTIONS
- ❑ EMERGENCY VEHICLE PREEMPTION (EVP)
- ❑ INTERCONNECT (TELEPHONE OR CABLE)
- ❑ EQUIPMENT CONDITION
  vertical and horizontal detection zones and detector placement
- ❑ FIRE HYDRANTS
- ❑ **CHECK LEFT TURN RADIUS**
- ❑ POLE SHOULD BE 4' FROM PED RAMP (NEAR 4' X 4' LANDING AREA)
- ❑ CHECK HANDHOLES
- ❑ ROADWAY MARKINGS, ARROWS ON ROADWAY
- ❑ GROUND MOUNT OVERHEAD SIGNING
- ❑ SIDEWALK/PATHS
- ❑ VISIBILITY OF INTERSECTION, ENTERING VEHICLES, SIGNS, INDICATION FOR EVP & AWF
- ❑ TOPOGRAPHY (SLOPES, GRADES, ETC.)
- ❑ BUSINESS OR RESIDENTIAL
- ❑ ADJACENT INTERSECTIONS
- ❑ ROADWAY CONDITION
- ❑ BUILDINGS
- ❑ RAILROAD OR EMERGENCY PROVIDERS IN AREA
- ❑ CABINET LOCATION – IF CABINET HAS HISTORY OF BEING HIT, RELOCATE IT
- ❑ LOCATION and CONDITION OF HANDHOLES
- ❑ BASIC GEOMETRY – LANE USAGE, LANE WIDTHS, DISTANCE CENTERLINE TO CURB, CORNER RADIUS
- ❑ WORK WITH OPERATIONS FOR LANE WIDTH AND NUMBER OF LANES
- ❑ CHECK PORK CHOP ISLAND TO MAKE SURE IT IS BIG ENOUGH (300 FT^2 – 400 FT^2)
- ❑ REVIEW ADA REQUIREMENTS

TRAFFIC FLOW

- ❑ TURN PROBLEMS/RESTRICTIONS
- ❑ QUEUES
- ❑ FAILED CYCLES (NOT ALL WAITING VEHICLES THROUGH ON GREEN)
- ❑ PEDESTRIAN ACTIVITY
- ❑ BUSES (STOP AREAS, FLOW, ETC.)
- ❑ SPEED LIMIT – USE POSTED SPEEDS

COMMENTS:

INTERSECTION DIAGRAM:

NORTH
ARROW

5.2 SOURCE OF POWER CHECKLIST

FIELD WALK / POWER COMPANY MEETING

CHECKLIST

T.H. _____at_____ Date

Designer_____ S.P.

Field Rep. Name, Title, Telephone, Address

_____

Power Company

TYPE OF CONSTRUCTION AND POSSIBLE IMPLICATIONS

Discuss construction staging, timberline of project and proposed letting date.

- ❑ New traffic control signal system
- ❑ Rebuild of existing system
- ❑ Major revision to existing system

TYPES OF SERVICE

- ❑ Use inplace service:
  - ❑ Overhead OR ☐ Underground
  - ❑ Pole Mounted OR Pad: ☐ Channel Mounted OR ☐ Enclosed Service Cabinet
  - ❑ 120/240 Volt OR ☐ 240/480 Volt
- ❑ Install new service:
  - ❑ Temporary service needed for staging
  - ❑ Permanent service
- ❑ Overhead OR ☐ Underground (come into cabinet underground)
- ❑ Pole Mounted OR Pad: ☐ Channel Mounted OR ☐ Enclosed Service Cabinet
- ❑ 120/240 Volt (signals) OR ☐ 240/480 Volt shared with lighting (discuss transformer needs)

DEFINE WHO IS RESP. FOR COST/MAINT. Of VARIOUS PARTS OF INSTALLATION

Conduit_____ Cables_____ Wood Poles_____

Transformer Pad_____ Transformer_____

LOCATION OF SERVICE AND CONTROLLER CABINET - TOPOGRAPHY OF AREA

Describe quadrant and define approx. location of transformer/pole/pad.

LUMINAIRES

- ❑ Pole mounted luminaires AND/OR ☐ Free standing light poles

Is freeway lighting system involved with project? If so, coordinate activities.

- ❑ Metered OR ☐ Unmetered

Agency paying power costs decides - refer to power co. policy.

ANTICIPATED SIGNAL SYSTEM LOAD: _____ Watts

Identify size of conductors (#2, #6, #0, etc.) needed for power to SOP (size wires for incandescent):_____

METER ADDRESS: _____

Confirm with source of power letter to power company. Get address from the power company or decide for yourself. Put address on the plans.

AGENCY RESPONSIBLE FOR PAYING CONNECTION CHARGES AND MONTHLY POWER COSTS: _____

Obtain cost estimate for connection charge if appropriate (Usually not charged).

The city is usually the payee.

5.3 TRAFFIC SIGNAL PLAN CHECK LIST

1 ☐ Title Sheet with Estimated Quantities (stand-alone projects) or
☐ Signature Sheet with Tabulations
2 ☐ Details
3 ☐ Temporary Intersection Layout and Matchlines
4 ☐ Temporary Wiring Diagram
5 ☐ Permanent Intersection Layout and Matchlines
6 ☐ Permanent Wiring Diagram
7 ☐ Interconnect Layout
8 ☐ Utility Plan Sheet
9 ☐ "For Information Only" Plan sheets

Project Number: SP XXXX-XX or SAP XX-XXX-XX

Project Location: XX@ XXXXXXXXXX

Date Reviewed: _____

Reviewer: _____

This checklist is for new, replacement, and revised traffic control signal systems.

Standards for phasing and plan conventions shall apply.

Plan Sheets shall be coordinate correct.

1. Title Sheet with Estimated Quantities or Signature Sheet with Tabulations

- ☐ Proper reference to specification: The 200**5** edition of the Minnesota Department of Transportation "Standard Specifications for Construction" shall govern.
- ☐ Sheet index (in proper order see index sheet).
- ☐ Charge ID written in pencil (Title Sheet on state let "stand-alone" plans only)
- ☐ Location map. Is it readable? List municipality and county. Intersection circled and labeled.
- ☐ North arrow pointing to the top, to the right, or somewhere in between.
- ☐ Project description accurate and complete. Intersections identified. City or County listed.
- ☐ Appropriate signature block (see standard title sheet).
- ☐ Proper SP, SAP, CP and Legislative route designation (see standard title sheet).For State Aid Projects use SP if there is Federal money, use SAP if there isn't any federal money
- ☐ Scale (see standard title sheet).
- ☐ Small project location map in the lower right corner with county and division (see standard title sheet), Federal number if appropriate.
- ☐ **Pay Items**:
  - ☐ Item numbers correct (see standard title sheet – delete items not needed) Item numbers in order.
  - ☐ (Blank line where numbers change (Example: 2104, Blank Line, 2165)
  - ☐ Separate pay items are needed for each EVP system and for each traffic control signal system or signal revision.
  - ☐ Separate ADA PAY ITEMS on stand-alone signal projects. Get appropriate numbers from the Signal Design Project Manager.
  - ☐ Separate Remove Signal System Pay Item for existing traffic control signal system removal or in Special Provisions as "Incidental". Cannot use the wording incidental to Traffic Control Signal System. If more than one signal use the wording, "Included in the Traffic Control Signal System A or B or C Pay Item" to distinguish from other systems.
  - ☐ Interconnect as a separate pay item or listed in general notes as; Included in the Traffic Control Signal System Pay Item or Revise Signal System pay item on the plan and in the special provisions.
- ☐ Most current version of symbols, abbreviations, and standard plates for traffic signals (see standard title/ signature sheet)
- ☐ Use "Licensed Professional Engineer" and "License. No." in the signature block.*Do not need scale of all sheets on the title sheet (Tim Swanson 3/9/00)

Special considerations:

- ☐ Metric plan Note: "Attention this is a Metric Plan" Minnesota Metric Symbol on each sheet.
- ☐ State Aid plan State aid signature block.
- ☐ Consultant designed plans Consultant name, logo and signature on each sheet.
- ☐ Warning Gas Pipeline Present note if gas line in the area.

2. Details

These standard MnDOT Metro Division details are available in Metric and English in Micro Station format on the metro traffic website and should be included as appropriate for traffic.

- ☐ MnDOT System ID #'s that each detail applies to.
- ☐ Proper SP, SAP, and /or CP signature block, page number units on each detail sheet.

☐ **Equipment Pad Layout Detail**

- ☐ Is the most current version as posted on MnDOT web page
- ☐ Shows both Signal Controller Cabinet and Signal Service Cabinet
- ☐ Pad type called out should match description in spec book, section 2565.3R.
- ☐ Separate Lighting Cabinet shown (if required).
- ☐ All cabinets are properly spaced to allow required access for personnel as per the National Electrical Code

SEE SAMPLE FROM CO/ADA

☐ **Concrete Work and Ped Ramp Detail (20 scale drawing) (stand-alone projects only)**

- ☐ MnDOT System Id No and
- ☐ TE No that it applies too
- ☐ **Advance Warning Flasher Detail (if required)**
  - ☐ Location properly noted on plan for posted speed of area.
  - ☐ Pay as included in the Traffic Control Signal System Pay Item.

- ☐ **Traffic Signal Pole Wiring Connector Detail**
  - ☐ Is the most current and appropriate version as posted on MnDOT Web Page
  - ☐ Includes in the color code any conductors unique to the installation
  - ☐ All MnDOT System Id No's and TE No's that it applies too.
- ☐ **Pole Mount Detail**
  - ☐ Is the most current version as posted on the MnDOT Web Page (the pedestal portion of this detail is not required if there are no pedestals in the plan)
- ☐ **Accessible Pedestrian Signal (APS) Pedestrian Push Button Detail**
  - ☐ Is the most current version as posted on MnDOT Web Page
- ☐ **Type D Sign Detail Mast Arm Signing and Pavement Marking**
  - ☐ Check all R – Series signs. (Flashing Yellow Arrow, yield on green, one-way, and NO PED Signs)
  - ☐ Designed by Sign CAD or with appropriate highway font.
  - ☐ Any inplace signing need to be removed or adjusted; salvaged and installed.

- ☐ Use mast arm signing program as appropriate.
- ☐ Note payment of signing. On stand-alone projects it is included in the traffic control signal system pay item.
- ☐ Note payment of pavement marking and/or removals. On stand-alone projects it is included in the traffic control signal system pay item.
- ☐ Insure that Pedestrian Crosswalk Markings do not include stop bars.

The following details are available if requested. Contact the Signal Design Project Manager

- Temporary wood pole system
- Pavement marking – Note correct quantities within note.
- Mast arm signing (English only)
- Conduit attachments for bridges
- Signal pole foundation in rock
- Stand- alone luminaires
- Microloop details
- Camera Mount Details
- Fiber Optic Details

3, 4, & 5 INTERSECTION LAYOUT AND MATCHLINES

- ☐ Intersection layout and matchlines should have the mainline roadway (usually the Trunk Highway) horizontally across the plan sheet.
- ☐ The north arrow should be pointing up or to the right of the sheet.
- ☐ All text is oriented to bottom or to the right.
- ☐ Traffic control signal system ID number - Get from Mn\DOT signal design project manager.
- ☐ Meter Address - Get from the power company.
- ☐ TE number. Get from Mn\DOT signal design project manager
- ☐ North Arrow.
- ☐ Bar Scale: 1" = 40' (English), 1:500 (metric)
- ☐ Proper Heading
- ☐ Signature Block (Lower Right Corner).
- ☐ Proper SP and/or SAP
- ☐ Correct sheet number.
- ☐ Consultant logo if externally designed.

- ☐ Streets named - easy to read. in proper naming order-

  (1st) Interstate Hwy, (2nd) US Hwy, (3rd) Mn Hwy, (4th), CSAH, (5th) CO RD, (6th) City St.

  Examples: TH 35E @ TH 13 (Sibley Memorial Hwy)

  TH 61 @ CSAH 68 (White Bear Ave)/ CR 146 (Hoffman Rd)
- ☐ Posted speed limit noted on roadways.
- ☐ Lane assignment arrows shown & correct.
- ☐ R/W should be shown.
- ☐ If there is an interconnection plan the Master ID No should be shown on every sheet.
- ☐ **Controller phasing (see sample sheet for appropriate labeling).**
  - ☐ Should be located in the lower left of sheet.
  - ☐ Tied to proper phasing (right turn rule).
  - ☐ Pedestrian indications shown - number pedestrian signal heads per phase as you approach the intersection with the number 1 being on the right. These numbers should be preceded by a P and a controller phase number.
  - ☐ Pedestrian pushbuttons shown - number pedestrian pushbuttons per phase as you approach the intersection with the number 1 being on the right. These numbers should be preceded by a PB and a controller phase number.
  - ☐ (A1, D1) APS Control Unit Address shown if plan contains APS
  - ☐ North arrow consistent with plan view.
  - ☐ Check phasing and opportunity for overlaps.
  - ☐ Show signal pole numbers.
  - ☐ Indications desirable or necessary on divided highway medians.
  - ☐ Push buttons are necessary on medians wider than 6’.
  - ☐ Additional consideration is required in school areas.
  - ☐ Check pushbutton location with respect to crosswalks, bike paths and ADA Guidelines
  - ☐ If using split phasing use convention of phases 3 and 4.
  - ☐ If EVP is present there should be pedestrian push buttons on the mainline.
- ☐ **Traffic control signal system Operation Notes (In the vicinity of the controller phasing chart)**
  - ☐ The traffic control signal system flash mode is all red.
  - ☐ Normal operation is __ phase, with phase(s) __ being a protected/permissive left turn phase(s), with phase(s) __ being a protected left turn phase(s), with phase(s) __ being flashing yellow arrow(s) by time of day or Split Phase
  - ☐ Phases __ and __ shall be on vehicle recall.
  - ☐ R. R. preemption noted.
  - ☐ Overlaps

- ☐ **Signal Head Chart**
  - ☐ Correct placement of heads (see charts).
  - ☐ Placed for maximum visibility (use overlays).
  - ☐ Numbering correct – put phase number in a circle. Number vehicle signal heads per phase from near to far and right to left as you approach the intersection. Signal heads should be numbered with the controller phase first followed by the head number. Protected/Permissive left turn signal heads should be labeled as through phases.
  - ☐ Signal head chart located on right side of plan sheet.
  - ☐ Signal head chart is consistent with layout locations.
  - ☐ LED noted in signal head chart notes
  - ☐ Background Shields noted in signal head chart notes
  - ☐ Black poly-carbonate heads noted in signal head chart notes
  - ☐ Size of indications noted in signal head chart (12”).
  - ☐ Signal arrows pointing in the correct direction.
  - ☐ Flashing Yellow Arrows (FYA) in right chart
  - ☐ Show signal head phasing diagram for 5 section heads both standard 5 Sec and 5 Sec Cluster type
  - ☐ Symbols on signal head chart – new or salvaged and install shall be filled in and inplace shall be open.
- ☐ **Detection**
  - ☐ Accurate detector locations for geometrics, speeds and planned operation (are counting/system detectors needed).
  - ☐ Distance from crosswalk or stop bar specified.
  - ☐ Size specified (6 feet x 6 feet typical).
  - ☐ All detectors labeled - Number detectors per phase as you approach the intersection and from right to left with the number 1 usually a detector back from the stop line and number 2 to the left. At the stop line number 3 would be in the right lane with number four to the left. These numbers would be preceded by a D and the
  - ☐ Controller phase number. If there is more than one detector in the turn lane the first one you approach is the lower number.
  - ☐ Loop chart accurately related to plan views (upper right corner).
  - ☐ Special detector types listed in chart. (microwave, sonic, radar, video)
  - ☐ If operated by DOT functions not included in chart.
  - ☐ Separate 2/C#14 (loop lead-in) for each detector (Exceptions: left turn lanes with 4 loops use 2 loops per cable, some cross street loops may use 2 loops per cable)

- ☐ Detector design must guarantee green and extension of green. Special attention needs to be given that lanes operating in non-lock be given ample detection coverage to allow for variable stopping locations. Loop detector locations should be designed based on the posted speed.
- ☐ Maximum of 24 loop detectors per cabinet.

☐ **Luminaire Extensions**

- ☐ Orient luminaire on mainline mastarm at 350 degrees to light cross street signing.
- ☐ Number in a triangle, the luminaires clockwise, with respect to the controller cabinet with number 1 being the first luminaire on a signal base.

☐ **Preemption EVP**

- ☐ Wired for all intersections.
- ☐ Does city want full installation?
- ☐ Detectors and confirmatory lights at all approaches (no two way detectors unless approved).
- ☐ Cable shown in the wiring diagram. (3/c #14 and 3/c #20 (TO EVP HUB)
- ☐ Symbols in the proper places on the intersection layout sheet.
- ☐ Mounting details given (use a note on permanent system and a detail on temporary wood pole system).
- ☐ Proper phase noted.
- ☐ *3/C #14 for light.
- ☐ *3/C #20 for detector.
- ☐ Check geometrics for adequate optics – is there a need for advance detection?
- ☐ EVP hub should be 6’ (1.8 m) from end of mastarm
- ☐ Identify all equipment and wiring related to EVP with an * or other symbol because it is a separate pay item and refer to the* in the general notes.

☐ **Preemption Railroad**

- ☐ Does operation match technical memo?
- ☐ Is agreement needed and has the agreement been negotiated?

General Notes: (Use where appropriate).

Permanent Systems

- ☐ 1) See special provisions for state furnished materials.
- ☐ 2) The exact location of handholes, poles, pedestals, pedestrian push button stations, loop detectors, and equipment pad shall be verified in the field by Mn\DOT Traffic Office Personnel.
- ☐ 3) Any signing notes (type, name, orientation, and location).

  For type "D" signs and pavement markings (See sign detail) all signing and pavement marking included in the traffic control signal system pay item.
- ☐ 4) All loop detectors shall be preformed PVC loop detectors.
- ☐ 5) All new conduits shall be Schedule 80 PVC or HDPE and carry a 1/c# 6 Insulated Green grounding conductor where shown in the plan.

  (Note: bare ground wire is not allowed and this must be an insulated green #6 wire that is not taped green. Only conductors #4 and larger are allowed to be taped green according to the National Electrical Code.)
- ☐ 6) Necessary pedestrian ramp or sidewalk construction notes.

  Note: these do not need to be on the layout if curb ramps and sidewalk are shown on separate sheets within the plan or on sheets within the construction plan.
- ☐ 7) Any salvage or removal notes.
- ☐ 8) Reference to any necessary details.
- ☐ 9) Pavement marking and signing are included in the Traffic Control Signal System pay item. (This note should be on pavement and signing sheets)
- ☐ 10)(Revision projects) Work to be done under this project shall be noted with a symbol, boxed, made bold and highlighted.
- ☐ 11) When there is a separate interconnect pay item and you want to show the interconnect cable on the layout sheet add the note "Items denoted with a ** are included in the interconnect pay item". If not a separate pay item should it should be stated in general notes that it is included in the Traffic Control Signal System Pay Item.
- ☐ 12) Items denoted with a * are included in the EVP System Pay Item.

Temporary Wood Pole Systems

- ☐ 1) See special provisions for state furnished materials.
- ☐ 2) Use this note for MnDOT administered projects: The exact location of handholes, poles, pedestals, pedestrian push button stations, loop detectors, pedestrian curb ramps, and equipment pad shall be determined in the field by Mn\DOT Traffic Office Personnel.
  - ☐ Use this note for non MnDOT administered projects: The exact location of handholes, poles, pedestals, pedestrian push button stations, loop detectors, pedestrian curb ramps, and equipment pad shall be verified in the field by Mn\DOT Traffic Office Personnel.
- ☐ 3) For traffic control signal system span wire mounting see detail sheet no. __.

- ☐ 4) Pavement markings (stop lines) are either included in the Temporary Signal System Pay Item or listed as by others see construction plan. (Approximately __ Lin. Ft.)
- ☐ 5) The contractor shall be responsible for coordinating the arrangement of the power connection.
- ☐ 6) EVP detector and confirmatory light shall be mounted as directed by traffic office personnel.

  (Span wire mounting or pole mounting as shown in detail on sheet no. __).

Conduit runs (All new conduits to be Schedule 80 PVC or Schedule 80 HDPE)

- ☐ Conduit size and cables listed.
- ☐ Correct symbol for inplace conduit.
- ☐ Correct symbol for proposed conduit.
- ☐ Conduit fill less than 40% for rigid and 35% for PVC
- ☐ No conduit smaller than 2” unless for detector cables only.
- ☐ 4” Conduit out of ground mount cabinets.
- ☐ 4” minimum size conduit under all public traveled roadways.
- ☐ All conduits from signal cabinet and signal service cabinet listed including stub outs for future use.
- ☐ Conduit runs for interconnect should be as straight as possible.
- ☐ All conduits except those within pads shall drain.
- ☐ Primary power shall be in a separate conduit run and separate hand holes.
- ☐ Size of bends and elbows in conduit in accordance with National Electrical Code and UL guidelines.
- ☐ If conduit is suspended under a bridge, does the distance between supports conform to NEC, is a hanger detail given in plan, and are expansion fittings called for?

  Note: Normally Rigid Steel Conduit is used for this application. If PVC used the hangers must be designed for use with PVC in order to insure expansion and contraction. The number of expansion joints shall be determined by the requirements within National Electrical Code.
- ☐ Conduit placed under inplace pavement does not need to be labeled (bored or pushed)
- ☐ Allow for spare wires (typically, 6 or more spares per pole)

Note: you cannot run coax cable in the same conduit as the class 1 electrical circuits. This is a NEC code violation.

Handholes

- ☐ Uniquely numbered - number clockwise with respect to the controller cabinet with number 1 adjacent to or nearest the controller cabinet.
- ☐ Two handholes located near cabinet (usually within 30').
- ☐ Primary power into the handhole located near the service equipment.
- ☐ Handhole spacing maximum 300' apart, but max of 100' if one or more 90 degree run.

Signal base locations

- ☐ Conform to visibility requirements of MMUTCD (check with overlays).
- ☐ Eliminate conflicts with pedestrian ramps.
- ☐ Identifying number in a hexagon - begin with number one in the quadrant closest to the cabinet. Number clockwise with respect to the controller cabinet.

Pole Notes - This general order should be followed but unusual circumstances may require modifications. Not all items listed here shall be required for every project. R10-12 signs (left turn on green) or R10-X12 signs (flashing yellow arrow) should be mounted adjacent to all five section heads or 4 section heads that are located on a mastarm. For design 'P' poles use design 'PA' base and add the comment to the plan and special provisions that the bolts need to be changed.

Mast Arm Poles

- ☐ X & Y Coordinates for ALL Mast Arm Poles
- ☐ PA_ pole foundation
- ☐ Type PA__-A-__D__-__ (Davit at 350 DEG)

  May require X instead of D where video cameras are mounted on top of pole (get from Signal Design project Manager.)
- ☐ 2 - Swing away hinges (required if on a house moving route)
- ☐ 1-Angle mount signal overhead at 0'
- ☐ __ Straight mount signal over head at __ 'and __'
- ☐ __ Angle Mount Signals at 90 and 180 DEG
- ☐ __ Angle Mount CD PED IND at 90 and 180 DEG
- ☐ __*EVP detector and confirmatory light (phase __) mounted __ from the end of mast arm (Special info if needed, standard is at 6')
- ☐ Luminaire __W HPS (Standard size is 250W HPS)
- ☐ __APS PB and sign (LT or RT ARROW (PB __-__) (If required)
- ☐ __-R10-12 sign adjacent to head _-_
- ☐ __-R10-12X sign adjacent to head _-_
- ☐ __-R9-3a sign (no-ped) facing pole(s) __

- ☐ __-R6-1L sign (one way)
- ☐ __-R6-1R sign (one way)
- ☐ Type D sign - (SEE DETAIL)
- ☐ Extend into HH __
    - ☐ __ "Conduit
    - ☐ __ -12/C# 14
    - ☐ __ -6/C# 14
    - ☐ __ -4/C# 14
    - ☐ *__ -3/C# 14
    - ☐ __ -3/C# 14 (LUM)
    - ☐ __ -4/C# 18
    - ☐ *__ -3/C# 20
    - ☐ __ -2/C# 14 (loop lead-in)
    - ☐ __ -1/C#6 INS GR
    - ☐ Other wire as needed

Pedestal Pole Notes

- ☐ X & Y Coordinates for ALL Pedestal Poles
- ☐ Station & Offset
- ☐ __' signal pole plus Pedestal Base
- ☐ __ Straight Mount Signal(s) at 90 and 180 DE
- ☐ __ Straight Mount CD PED IND at 90 and 180 DEG
- ☐ __APS PB and sign (LT or RT ARROW (PB __-__) (If required)
- ☐ Bracketing Type __. On new pedestal poles the only bracketing type used is Type 4A. It is only used if the design calls for a single ped head and no vehicle heads. For Revisions modify Bracketing on inplace plans.
- ☐ Extend into HH __
    - ☐ 3" Conduit
    - ☐ __-12/C#14
    - ☐ __ -6/C# 14
    - ☐ __ -2/C# 14 (loop lead-in)
    - ☐ __ -4/C# 14
    - ☐ __ -1/C#6 INS GR

Pedestrian Push Button Stations

- ☐ X & Y Coordinates for ALL Push Button Stations
- ☐ PUSH BUTTON STATION
- ☐ 1- APS PB AND SIGN
- ☐ (RT, DBL, or LT ARROW) PB_-_
- ☐ Extend into HH __
  - ☐ 2” Conduit
  - ☐ 1-2/C#14 (loop lead-in)

Temporary Wood Pole Standard Notes

- ☐ Station & Offset
- ☐ __Ft. wood pole (class 2)
- ☐ 2 down guys, guards & anchors
- ☐ __Type__pole mounted
- ☐ EVP detector and confirmatory light (phase__)
- ☐ __Ft. mast arm & luminaire - __W HPS with PEC
- ☐ __Ped PB & sign (R10-4B)
- ☐ __R9-3a sign(s) (no ped) facing pole(s) __
- ☐ __R10-12 sign adjacent to head _-_
- ☐ Metal junction box with terminal block
- ☐ 2” Riser with weatherhead above junction box with
  - ☐ __-12/C# 14
  - ☐ __ 6/c # 14
  - ☐ __ -3/C#14
  - ☐ __ -4/C#18
  - ☐ __ -3/C#20
  - ☐ Other wire as needed
- ☐ 2” Riser with weatherhead and conduit to HH __with __4/C#18
- ☐ ¾” PVC to ped PB with__ 2/C#14 (loop lead-in)
- ☐ 1” PVC riser with weatherhead above span wire with __3/C#14 (LUM)

Geometrics

- ☐ Is there a need for additional signal faces, loop detectors, warning signs or flashers?
- ☐ Place handhole away from possible future construction.
- ☐ Is all canalizations, stop lines, and in a proper place for pedestrian walkways
- ☐ Pedestrian ramps and sidewalks noted or shown on a separate 20 scale drawing.
- ☐ APS Push buttons and stations located appropriately.
- ☐ Lane lines and directional arrows shown.
- ☐ Right of way lines are necessary.
- ☐ Check for turning conflicts.
- ☐ Check for adequate sight distance for EVP detectors and EVP impacted by vertical grade.

Voltage Drops

- ☐ Check maximum NEC recommended allowable drop from SOP to controller cabinet, 3% of nominal line voltage.
- ☐ Check maximum allowable from controller to signals, 3%.
- ☐ Check both drops combined must be less than 5%.
- ☐ Check maximum voltage drop allowable from SOP or signal or lighting service cabinet to luminaires is 3%.
- ☐ Calculations on proper form in project file.
- ☐ Note on plan if any drops are excessive. Also compute required wire sizes which do not exceed voltage drop %

Source of Power

- ☐ Location noted as B.
- ☐ Coordinated with local electrical company.
- ☐ SOP checklist enclosed (application for power initiated if applicable).
- ☐ Are luminaires metered or not (note on Field Wiring Diagram)?
- ☐ Specify clearly who will do any necessary transformer work.
- ☐ Note who will supply the wood pole.
- ☐ Write SOP letter to power company
- ☐ Application for power, if necessary should be made by the agency that will be paying for the initial service and the monthly bills.

Controller Cabinet/Equipment Pad

- ☐ Location noted as A.
- ☐ Appropriate detail showing pad layout, wiring and grounding, standard notes.
- ☐ Drawing contains proper notes and standard conduit arrangement.
- ☐ Check proper location/ orientation.
- ☐ Verify conduits match directionally with the Intersection Layout
- ☐ Three (3) ft of working clearance in front of all doors on all cabinets (NEC Requirement)

4, 5, & 6. WIRING DIAGRAMS

General information

- ☐ Sheet number and proper sheet labeling.
- ☐ SP and/or SAP numbers given.
- ☐ Proper intersection identification.
- ☐ Signature block and/or consultant logo.
- ☐ Traffic control signal system ID and meter address.
- ☐ Controller in center of sheet (usually).
- ☐ TE number.
- ☐ Master controller ID number and show master controller inside the controller box. (if present)
- ☐ Conductor color code chart is included other option is to include a note stating the color code is on the Traffic Pole Base Connector Detail.
- ☐ All signal bases, signal heads, ped indications, luminaires, pushbuttons, EVP, cameras & detectors called out on
- ☐ Phase (s) for EVP light should be on wiring diagram.
- ☐ Hand holes, manholes, and junction boxes labeled properly.
- ☐ Cable quantities and types shown agree with descriptions on intersection layout.
- ☐ Service wires from SOP properly labeled and ground rod(s) specified.
- ☐ Designations for loads are the same at both ends of each cable.
- ☐ Cables correctly traced from controller cabinet to loads.
- ☐ Interconnect cables should be numbered in the 90's to avoid confusion.
- ☐ Wiring diagram complements equipment pad wiring diagram if that is given in detail sheets.
- ☐ Possible need for AWF?
- ☐ Provide spares for possible future 4 or 5 section heads.
- ☐ In/out cable configurations are not allowed - add cable if necessary.
- ☐ Neutrals on all cables are not shared in pole bases.

- ☐ Design in spare cables for pedestrian heads and buttons, even if there isn't any ped x-ings this time.
- ☐ Should have only one pedestrian x-ing a major roadway, unless there are designated sidewalks or trails on both sides of the street
- ☐ For revised traffic control signal systems when it is necessary to re-label the numbering of inplace items use the note "Re-label the wiring for the inplace loops, heads, and poles, to match MnDOT's standard numbering system, as shown".
- ☐ List mainline heads left to right and top to bottom on a 12/C wire. Ideally there should be a separate 12/C wire for cross streets.
- ☐ 4 and 5 Section heads should be listed at top of 12/C as per color code.
- ☐ Ground rod connections shown correctly in handholes adjacent to signal poles and in bases of any pedestal poles.
- ☐ EVP confirmation lights must be on a 3/C #14 cable and shown as TO EVP HUB (no splice dots)
- ☐ There should be at least one set of spare wires for each phase.
- ☐ Wiring diagram should match wiring shown on the cabinet detail for the luminaires.

Wire Notes

- ☐ Cable symbols correct (3/C #14, 2/C #14 (loop lead-in), 3/C #20 all different, for example).
- ☐ Indications shown and head numbers match layout and Pole Base Connector Detail
- ☐ 1-1/c #6 INSULATED. GREEN to each pole base
- ☐ For Mast Arm Poles 1-1/c #6 INSULATED GREEN and Ground Rod are shown correctly at nearest HH
- ☐ For Pedestal Poles 1-1/c #6 INSULATED GREEN and Ground Rod are shown correctly in base
- ☐ Pedestrian Push Button Stations are shown on wiring diagram as PB STA (PB 2-1 etc) not identified with a pole number
- ☐ Each Ped indication shall have a separate 4/C#14 cable.
- ☐ Each Ped pushbutton shall be on a separate 2/C#14 (loop lead-in) cable. No splice dots is shown as TO PB
- ☐ Separate 2/C #14 (loop lead-in) for each detector. Can have two lops on one lead-in cable.
- ☐ EVP confirmatory light has own 3/C # 14 able.
- ☐ EVP detector 3/C #20cable (TO EVP HUB). No splice dots shown at base.
- ☐ Mast arm poles at least 2-12/C #14 (loop lead-in)
- ☐ Neutrals shown as heavier lines - Signal heads do not share neutrals.
- ☐ Provide spares for future expansion of system, if necessary, and label them.
- ☐ Correct symbols used for splices (dots)
- ☐ Check wiring - need 6 conductors for a standard 5 section head and 5 conductors for a 4 section head. 8 conductors 2 of which are neutrals required for 5 Section Multi Modal Heads.
- ☐ On wood pole systems separate 6/C #14 cables for each signal head.

7. Interconnect Layout Sheet

- ☐ English scale is usually 1” = 100’.
- ☐ Correct symbols.
- ☐ “For Information Only” sheets of each intersection that is interconnected.
- ☐ On “Interconnect only” projects ;separate Intersection Layouts and Filed Wiring Diagrams must also be Drawn.
- ☐ Show location of interconnect wire, conduit and controller cabinets which are impacted by interconnect.
- ☐ Designate the distance from the paved shoulder or curb to the cable.
- ☐ If handholes for interconnect are included in the traffic control signal system pay item, show the handholes as inplace on
- ☐ Use RSC when interconnect is within 10’ of guardrail or culvert - Note on plan sheets (use detail in signal design workbook).
- ☐ Identify if interconnect is installed on front or back of guardrail adjacent to roadway.
- ☐ Interconnect wires noted on layout – Notes included as appropriate to make payment clear.
- ☐ Fiber optic will require additional sheets.

General Notes:

- ☐ Contact R/W unit for R/W limits.
- ☐ Unless noted as inplace, all interconnect systems shall be furnished & installed.
- ☐ Distance off of shoulder for direct buried cable should be 1’ to 2’. (unless guardrail is present)
- ☐ Master ID No should be on every sheet of interconnect plan an on the plan sheets for the signal where it is located.

8. Utility Layout Plan Sheet

- ☐ Separate Utility Sheet (not shown on signal layout)
- ☐ Any plan with excavation must have a utility plan sheet or tabulation.
- ☐ Should also show right of way.
- ☐ Information must conform to state law (be less than 90 days old prior to letting).
- ☐ Check notes on sample plan

9. For Information Only Plan Sheets

- ☐ S.P. and/or SAP numbers/ CP numbers of proposed plan is included on plan sheet.
- ☐ Proper sheet number references for this plan.
- ☐ Noted as English units if appropriate. (convert Metric to English)
- ☐ Included for every existing traffic control signal system in the plan set.
- ☐ No signatures on this sheet. Cross off or obliterate previous engineering certifications (old signature, sheet #, description and SP).

6. PLAN DEVELOPMENT

6.1 GENERAL

The objective of this chapter is to present the fundamental procedures and standard practices related to the design of traffic control signal systems. The end product of the pre-construction activities in signal design is the Plan and Special Provisions. Supporting the plans and Special Provisions are the standard design practices, Standard Plates Manual, the Minnesota Standard Specifications for Highway Construction, other applicable national and local standards, and any necessary agreements.

6.1.1 Required Sheets

Standard signal design plans shall contain at least the following sheets:

- Title Sheet
- Estimated Quantities (if not shown on the title sheet)
- Details (may include one or more of the following)
    - Advance Warning Flasher Design
    - SSB Cabinet Pad Layout
    - Pole Mount Detail
    - Pole Wiring Connector Detail
    - Wood Pole Span Wire Detail
    - ADA Pedestrian Station
    - APS Push Button Mounting Detail
    - Pedestrian Curb Ramp Details
    - Signing and Pavement Markings Details
    - Other(s)
- Intersection Layout Sheet(s)
- Field Wiring Diagram(s)
- Interconnect Layout(s)
- For Information Only Sheet(s)
- Utilities

Section 6.3 in this chapter illustrates the various elements of the above plan sheets. An example of a typical signal design plan set is included in Chapter 12. The sample plan is available from the OTST website at:

www.dot.state.mn.us/trafficeng/signals/signalplansheets.html

6.1.2 Sheet Size and Scale

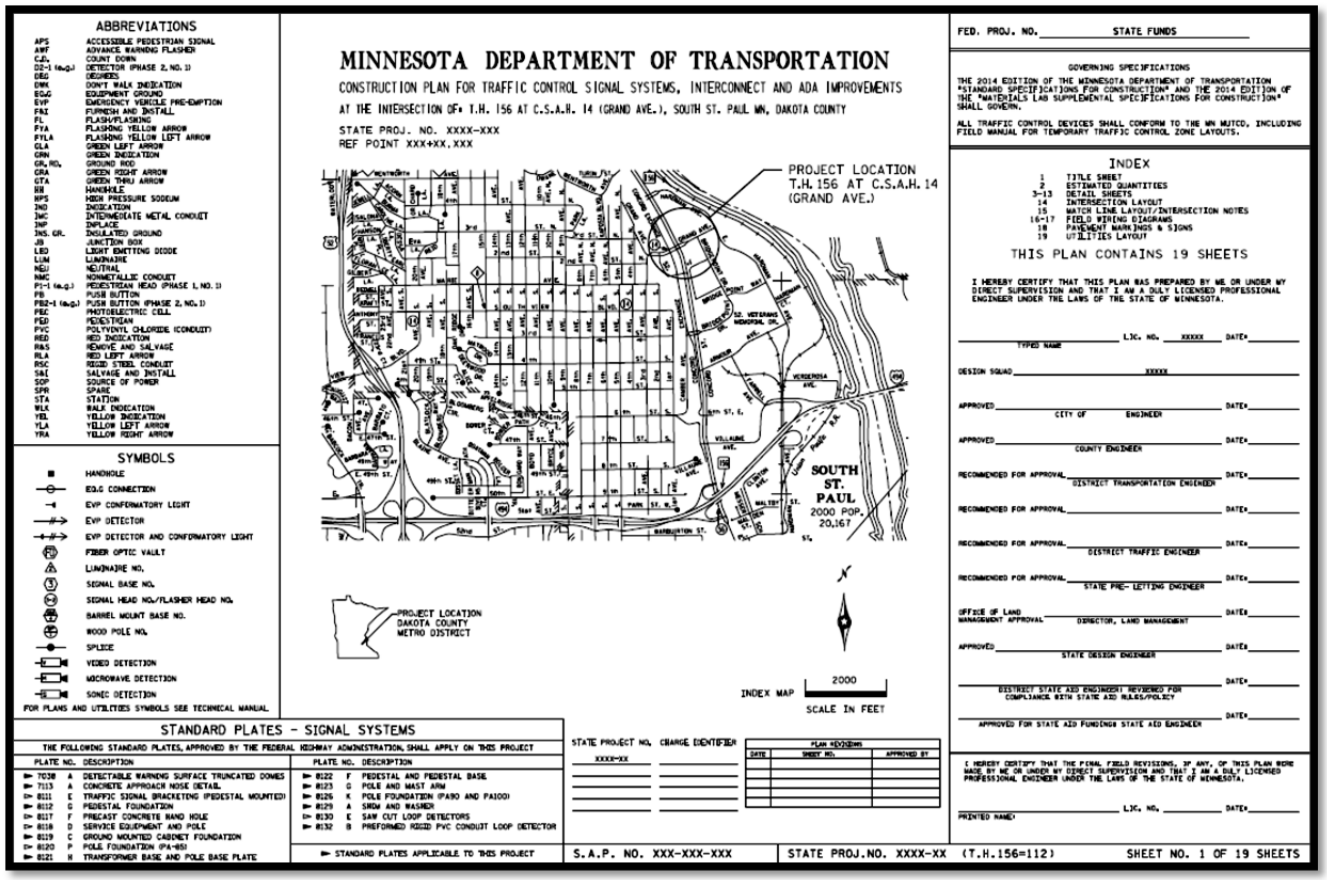
Final signal plans should be prepared on 11” x 17” plan sheets. The original title sheet shall be of mylar or vellum composition. The scale for the "Intersection Layout" should be 40 scale (1:500 metric), interconnect layouts can be 100 scale (1:1000 metric). Each sheet of the plan must be properly identified in the lower right corner (State Project or State Aid Project Number and Sheet XX of XX).

The licensed professional engineer responsible for or under whose supervision the work is performed shall sign the title sheet.

6.2 TYPICAL PLAN SETS AND COMPONENTS

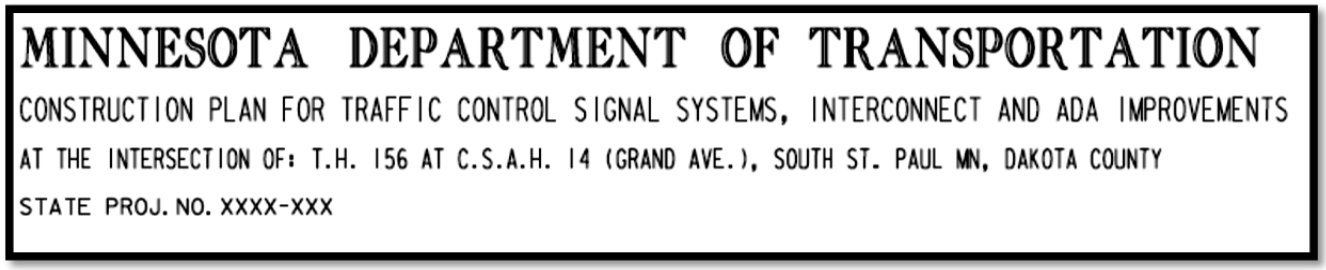
6.2.1 Title Sheet

The title sheet is required for all traffic signal plans. It includes information such as the title block, project location, governing specifications, etc. A sample title sheet is shown below. An 11”x17” copy of a title sheet is included in Chapter 12.



6.2.1.1 Plan Description and Location

This defines the type of work being performed and the location of the work. The location identified should list intersections from west to east or south to north.



6.2.1.2 Governing Specifications 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. Generally it is located in the upper right hand corner of the title sheet, under the federal project number or statement "state funds".

If designed in metric units, there must also be a statement to the left of this box: "attention, this is a metric plan".

GOVERNING SPECIFICATIONS

THE 2014 EDITION OF THE MINNESOTA DEPARTMENT OF TRANSPORTATION "STANDARD SPECIFICATIONS FOR CONSTRUCTION" AND THE 2014 EDITION OF THE "MATERIALS LAB SUPPLEMENTAL 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
3-13	DETAIL SHEETS
14	INTERSECTION LAYOUT
15	MATCH LINE LAYOUT/INTERSECTION NOTES
16-17	FIELD WIRING DIAGRAMS
18	PAVEMENT MARKINGS & SIGNS
19	UTILITIES LAYOUT

THIS PLAN CONTAINS 19 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.

6.2.1.3 Plan Preparation Certification Note

This identifies:

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

I HEREBY CERTIFY THAT THE FINAL FIELD REVISIONS, IF ANY, OF THIS PLAN WERE MADE BY ME OR UNDER MY DIRECT SUPERVISION AND THAT I AM A DULY LICENSED PROFESSIONAL ENGINEER UNDER THE LAWS OF THE STATE OF MINNESOTA.

_____ LIC. NO. _____ DATE: _____

PRINTED NAME:

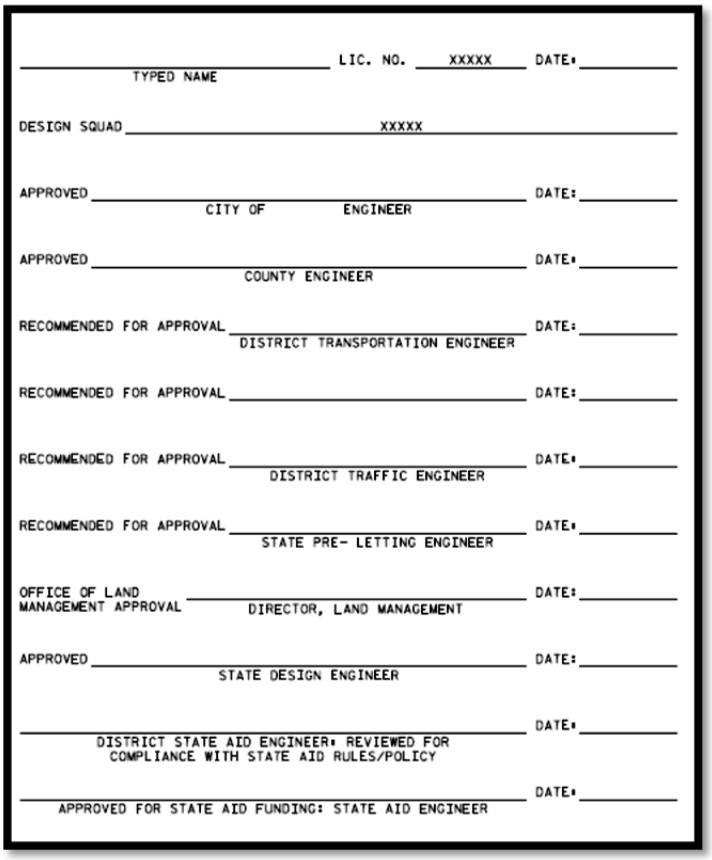
This block is located under the index of sheets.

STATE PROJ.NO. XXXX-XX (T.H.156=112) SHEET NO. 1 OF 19 SHEETS

Note: On the title sheet, after the state project number, the trunk highway and legislative route number must be shown in parenthesis (T.H. 795= ###) where ### is the legislative route number.

6.2.1.4 Signature Block

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



This block varies depending on the project type. The following signature lines are required for the varying project type:

Signature Line	Project Type		
	State Aid Plans	Cooperative Agreement	State Aid/Cooperative Agreement Plans
Jurisdiction Line	√	√	√
Blank Line	√	√	√
'For' District Line		√	√
Division Traffic Engineer		√	√
State Pre-Letting Engineer		√	√
Director of Land Management		√	√
State Design Engineer		√	√
Division-Assistant Engineer-State Aid	√		√
State Aid Engineer	√		√

For *Cooperative Agreement* and *State Aid* plans, all lines are required. Combinations of funding or jurisdiction will require different combinations of signatures.

This block is located under the Plan Preparation Certification note. The sample above is a Cooperative Agreement line since the first seven lines are used.

The blank line is required for all signature blocks. Line 1 is for the appropriate jurisdiction. Use multiple lines if needed for additional jurisdictions.

If line 8 and 9 are used, the text prior to the signature line shall read “Recommended for Approval”.

6.2.1.5 Project Numbers and Sheet Numbers

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.

STATE PROJ.NO. XXXX-XX (T.H.156=112) SHEET NO. 1 OF 19 SHEETS

A SP in the project number stands for State Project. A SP is necessary for any project on a trunk highway signal. A SAP is a State Aid Project number indicating that the local agency is using State Aid funds to finance their share of the project. If the project has federal funding the SAP becomes a SP. All state aid numbers should be listed on all sheets to which they apply.

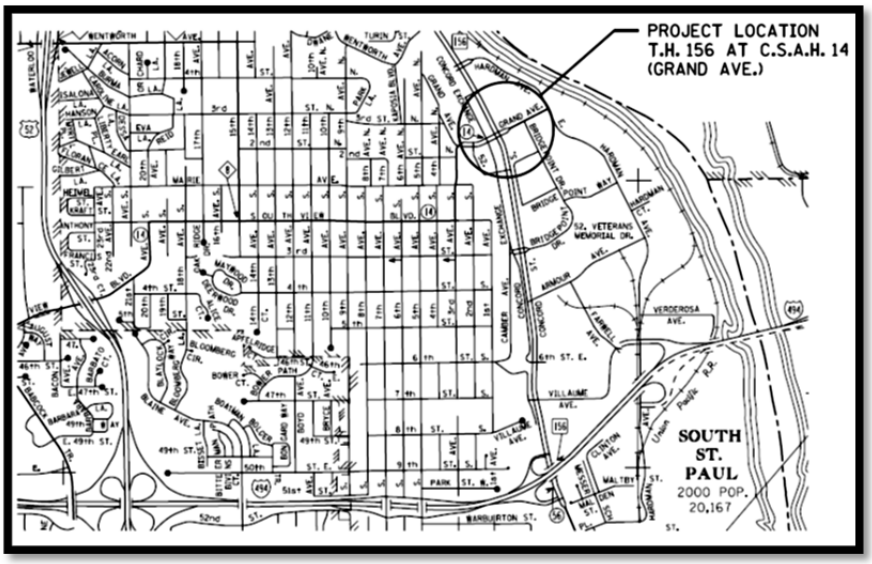
The general format for a SP is “CCNN-A”. CC is the county number in alphabetical order (i.e., Anoka County is 02). NN is the control section number within the county unique to the roadway in the County. A is the number of the project on that control section (i.e., -269 means that there have been 268 other projects on this section of roadway prior to this project).

The general format for an SAP is CCC-NNN-A. CCC is a 3-digit city number, a two digit number is a county number. NNN is a number related to the roadway and project type. A is the number of the project in that city or county of that type.

6.2.1.6 Index Map

The index map is used to identify the location of the project(s). Provide leader lines to the intersections or from the beginning and end of the project limits to the appropriate points on the map. This is generally located near the center of the title sheet.

If appropriate, identify all state aid project numbers applicable to the project. Also, label all traffic control traffic control signal systems.

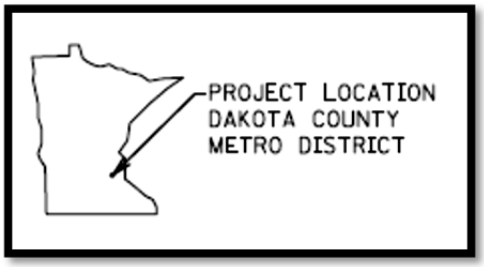


6.2.1.7

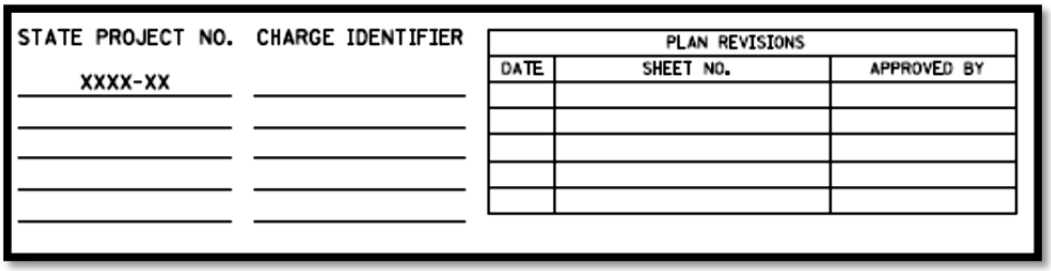
6.2.1.8 Project Location

The information included in this block is the generalized location (county and city). This is generally located in the lower right part of the title sheet, left of the signature block and above the project number block.

Note: if this is a metric plan, the mndot metric symbol shall appear in the lower right hand corner of the title sheet.



6.2.1.9 Plan Revisions Block



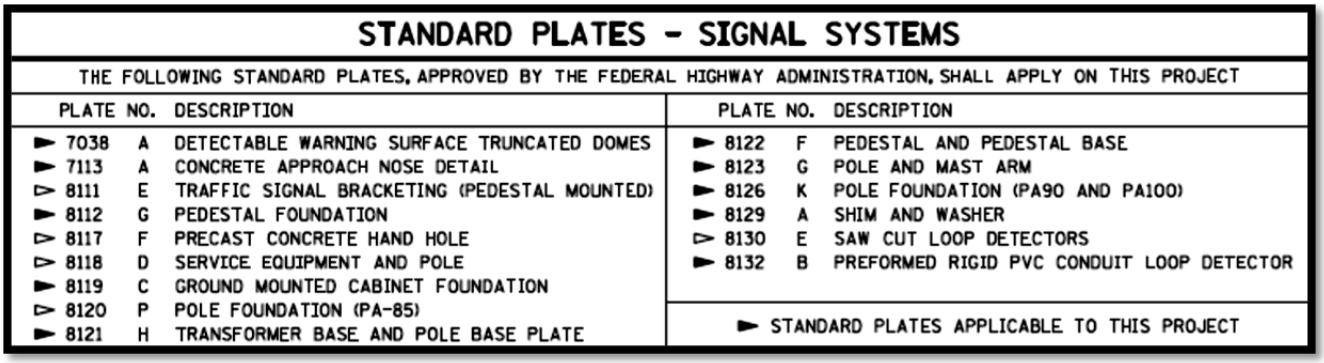
STATE PROJECT NO.	CHARGE IDENTIFIER
XXXX-XX	

PLAN REVISIONS		
DATE	SHEET NO.	APPROVED BY

The block is included so that future plan revisions can be documented. This is generally located in lower center portion of the title sheet. Pencil in the charge identifier number. MnDOT plan processing will edit this as necessary.

6.2.1.10 Standard Plates Summary

This identifies the list of Standard Plates that are applicable to this project. This is generally located in the lower left hand corner of the title sheet.



STANDARD PLATES - SIGNAL SYSTEMS

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

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

► STANDARD PLATES APPLICABLE TO THIS PROJECT

6.2.1.11 Plan Symbols and Abbreviations

ABBREVIATIONS

APS	ACCESSIBLE PEDESTRIAN SIGNAL
AWF	ADVANCE WARNING FLASHER
C.D.	COUNT DOWN
D2-1 (e.g.)	DETECTOR (PHASE 2, NO. 1)
DEG	DEGREES
DWK	DON'T WALK INDICATION
EQ.G	EQUIPMENT GROUND
EVP	EMERGENCY VEHICLE PRE-EMPTION
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
HPS	HIGH PRESSURE SODIUM
IND	INDICATION
IMC	INTERMEDIATE METAL CONDUIT
INP	INPLACE
INS. GR.	INSULATED GROUND
JB	JUNCTION BOX
LED	LIGHT EMITTING DIODE
LUM	LUMINAIRE
NEU	NEUTRAL
NMC	NONMETALLIC CONDUIT
P1-1 (e.g.)	PEDESTRIAN HEAD (PHASE 1, NO. 1)
PB	PUSH BUTTON
PB2-1 (e.g.)	PUSH BUTTON (PHASE 2, NO. 1)
PEC	PHOTOELECTRIC CELL
PED	PEDESTRIAN
PVC	POLYVINYL CHLORIDE (CONDUIT)
RED	RED INDICATION
R&S	REMOVE AND SALVAGE
RLA	RED LEFT ARROW
RSC	RIGID STEEL CONDUIT
S&I	SALVAGE AND INSTALL
SOP	SOURCE OF POWER
SPR	SPARE
STA	STATION
WLK	WALK INDICATION
YEL	YELLOW INDICATION
YLA	YELLOW LEFT ARROW
YRA	YELLOW RIGHT ARROW

SYMBOLS

■	HANDHOLE
—⊖—	EQ.G CONNECTION
—◄	EVP CONFIRMATORY LIGHT
—//→	EVP DETECTOR
—◄//→	EVP DETECTOR AND CONFIRMATORY LIGHT
FO	FIBER OPTIC VAULT
2	LUMINAIRE NO.
3	SIGNAL BASE NO.
3-2	SIGNAL HEAD NO./FLASHER HEAD NO.
BM 4	BARREL MOUNT BASE NO.
WP 1	WOOD POLE NO.
—●—	SPLICE
—V◄	VIDEO DETECTION
—M◄	MICROWAVE DETECTION
—S◄	SONIC DETECTION

FOR PLANS AND UTILITIES SYMBOLS SEE TECHNICAL MANUAL

These are the standard symbols and abbreviations pertaining to the traffic control signal system. This is generally located in upper left portion of the title sheet.

Other standard technical symbols can be found in the technical manual.

6.2.2 Quantity Sheet

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 traffic control signal system may be itemized separately from the traffic control signal system due to cost participation but is incorporated into the traffic control signal system pay item. A description of the cost participation policy is shown on the following page.

Note: Check with the signal design project manager to see if EVP is separated out.

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					

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

Refer to the TRNS*PORT Web Site (**http://bidlet.dot.state.mn.us/ItemSearch.aspx**) for a listing of the following:

- Item Number & Extension,
- Short Description,
- Long Description,
- Four Character Computer Code for the Unit Name, and
- Desired Plan Sheet Unit Name

State Aid participation should be clearly identified for each item.

Note: Haul Salvage material always has zero Federal cost participation and requires a separate pay item.

6.2.3 Details

The detail sheets show the standard details that are applicable to the project. They may include the following:

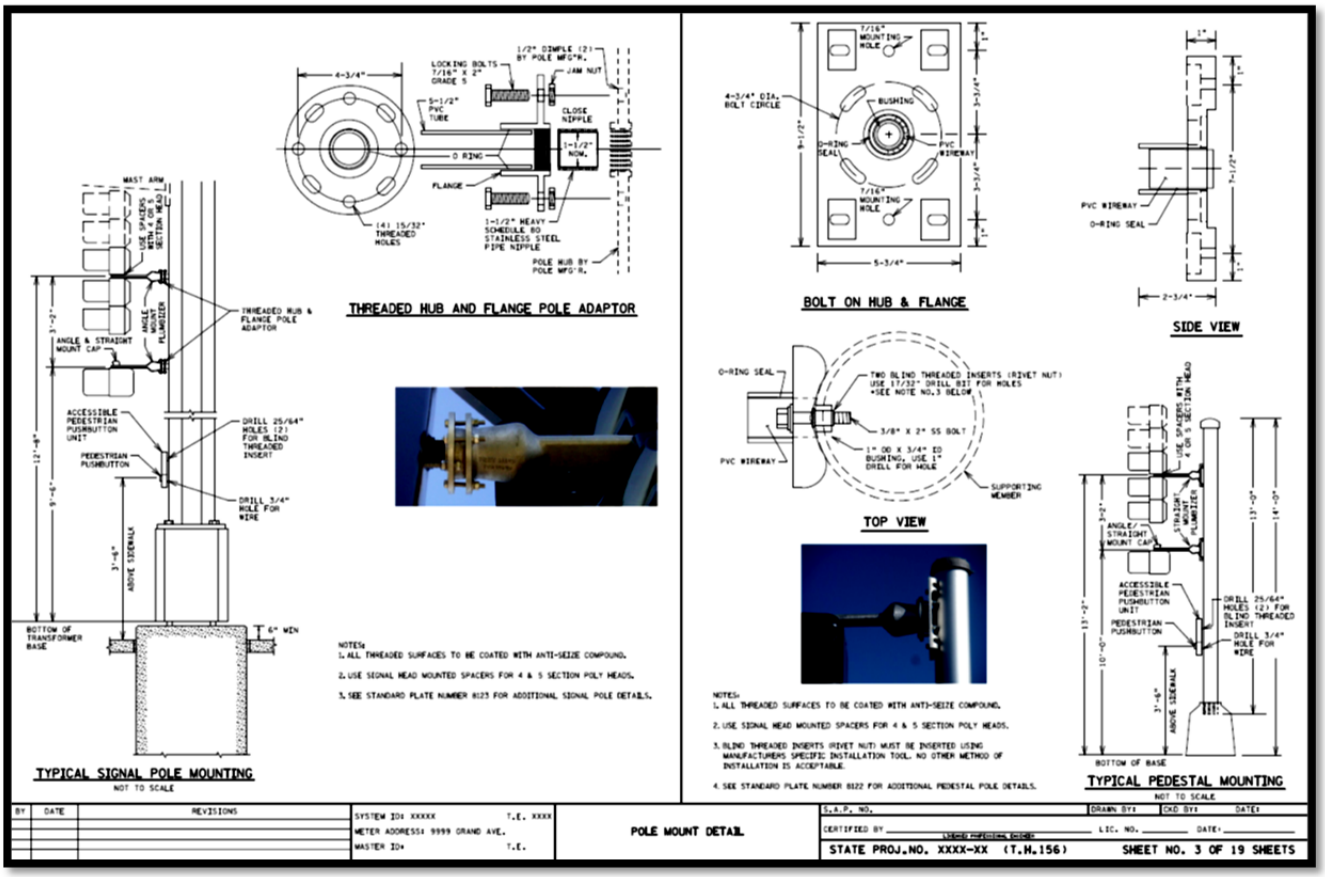
- APS Push Button Mounting Detail and APS Location
- SSB Cabinet Pad Layout
- Pole Wiring Connector Detail
- Fiber Optic Schematic
- Pedestrian Crosswalk Details
- Pedestrian Curb Ramp Details (multiple sheets)
- Pole Mount DetailWood Pole Span Wire Detail
- ADA Pedestrian Station
- Signing and Pavement Markings Details
- Type “D” and/or Type “C” sign details
- Advance Warning Flasher Design (not part of the sample plan)
- Camera Extension Detail (not part of the sample plan)
- Video Detection Camera Mounting (not part of the sample plan)
- Other(s)
- Any other details specific to the traffic control signal system (such as foundations in rock, flashing beacons, etc.). While standard details, the designer should ensure each is modified to fit the specific project.

The designer should ensure that the most current version of each detail is used.

Several example standard details are shown in following sections. An 11”x17” copy of these sheets is included with the sample plans in Chapter 12. The most up to date version of the details can be downloaded from,

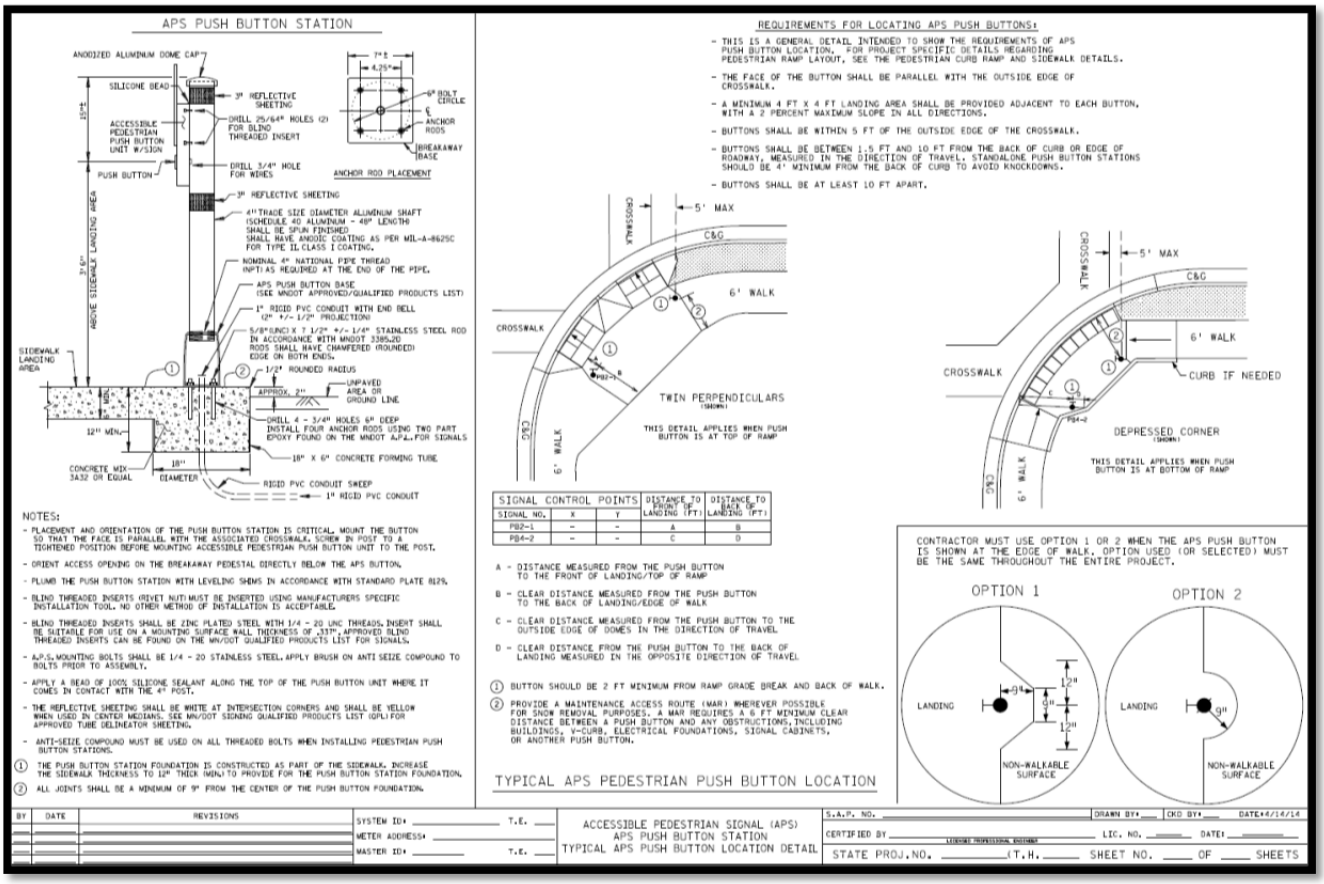
www.dot.state.mn.us/trafficeng/signals/signalplansheets.html.

6.2.3.1 Pole Mount Detail



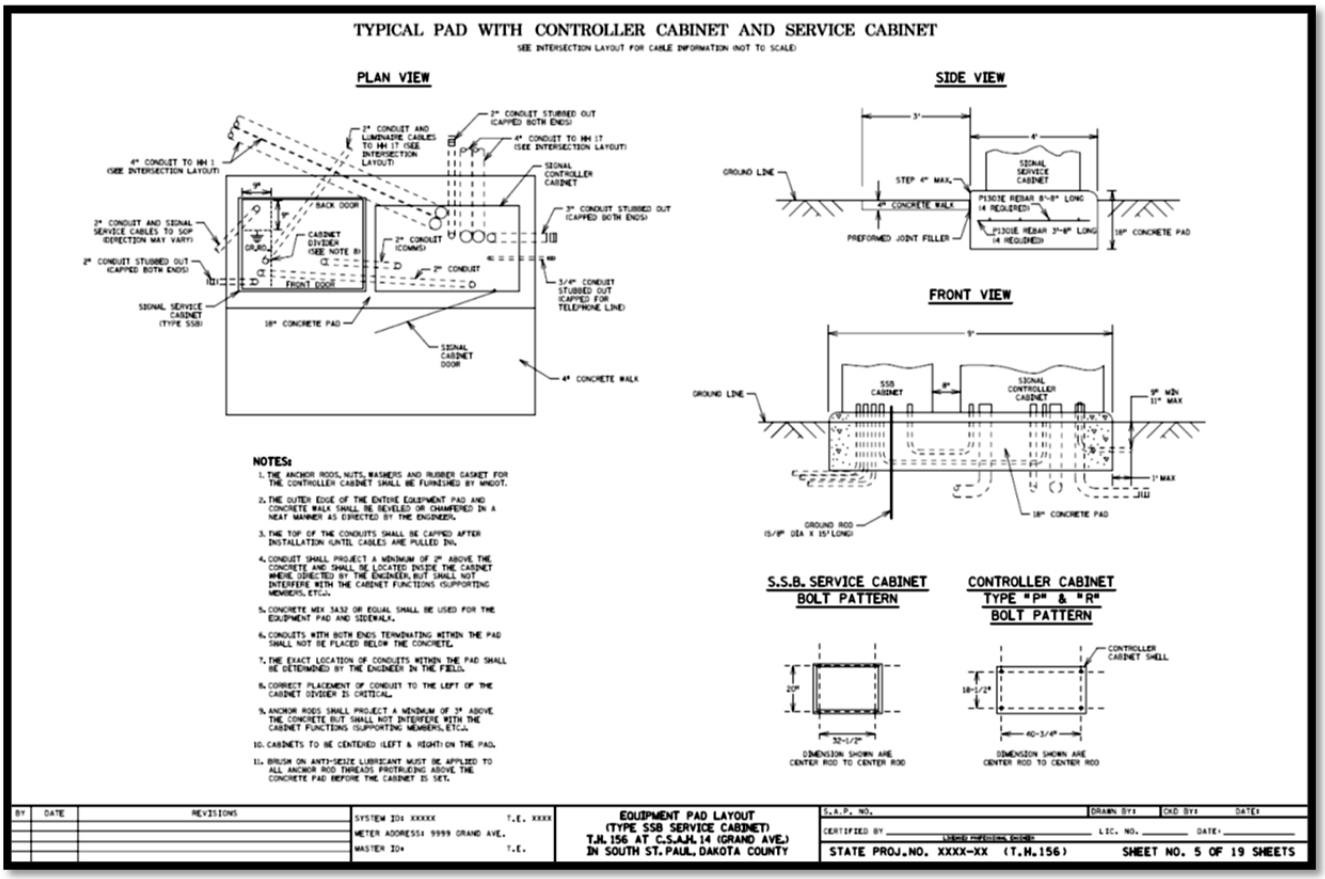
Refer to Chapter 12 for an 11” x 17” copy of the above plan sheet.

6.2.3.2 Typical APS Pedestrian Push Button Location and Push Button Station



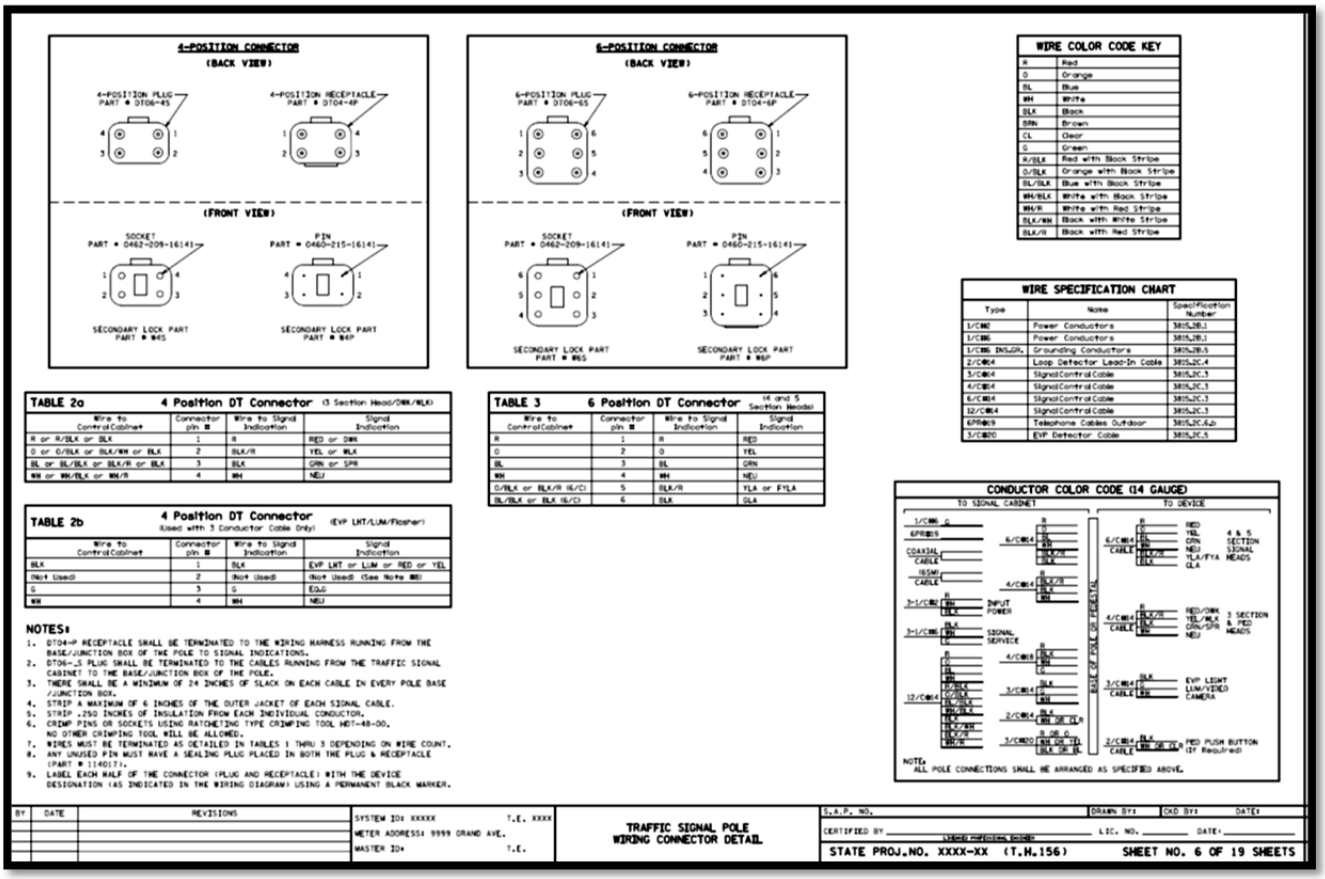
Refer to Chapter 12 for an 11” x 17” copy of the above plan sheet.

6.2.3.3 Typical Pad Controller and Cabinet Service Cabinet Detail



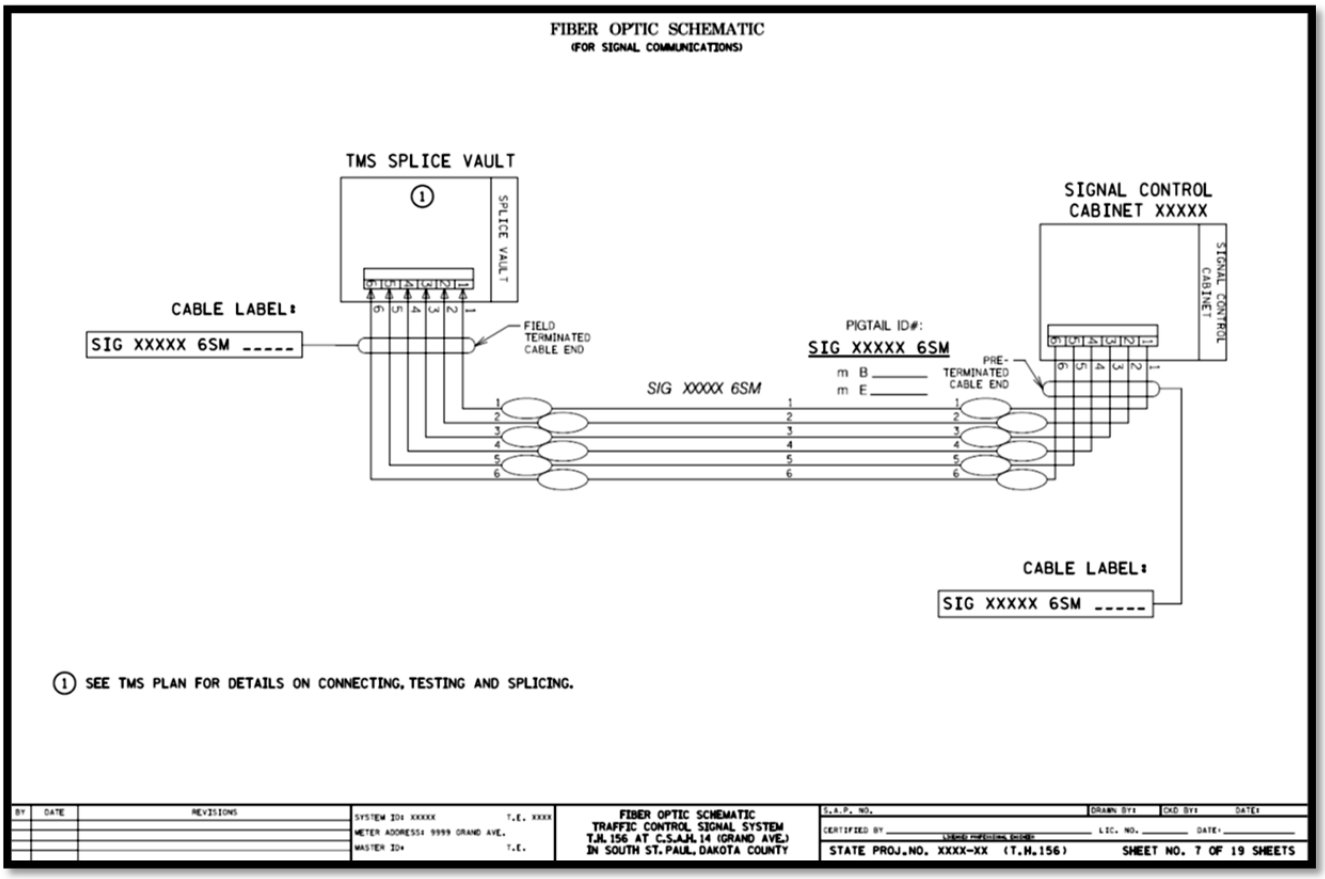
Refer to Chapter 12 for an 11” x 17” copy of the above plan sheet.

6.2.3.4 Traffic Signal Pole Wiring Connector Detail



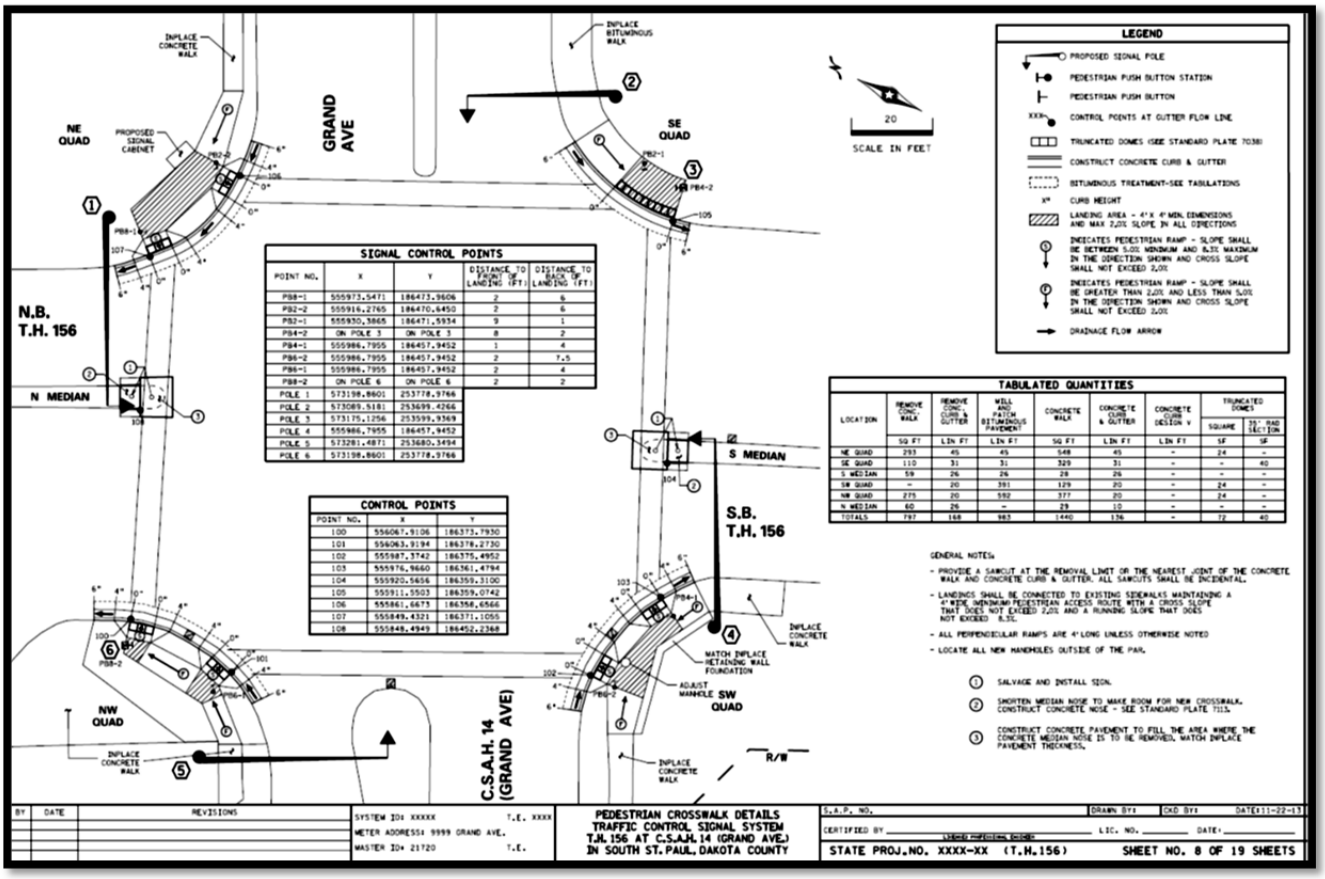
Refer to Chapter 12 for an 11” x 17” copy of the above plan sheet.

6.2.3.5 Fiber Optic Schematic



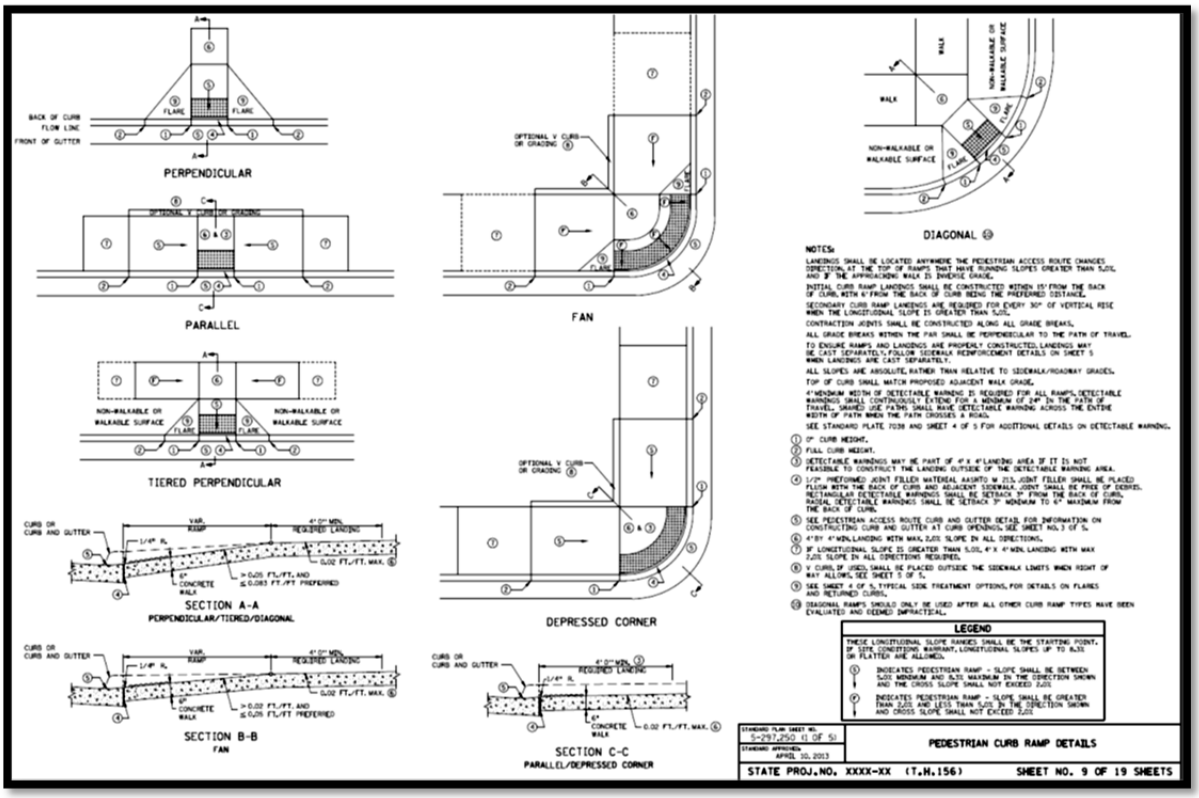
Refer to Chapter 12 for an 11” x 17” copy of the above plan sheet.

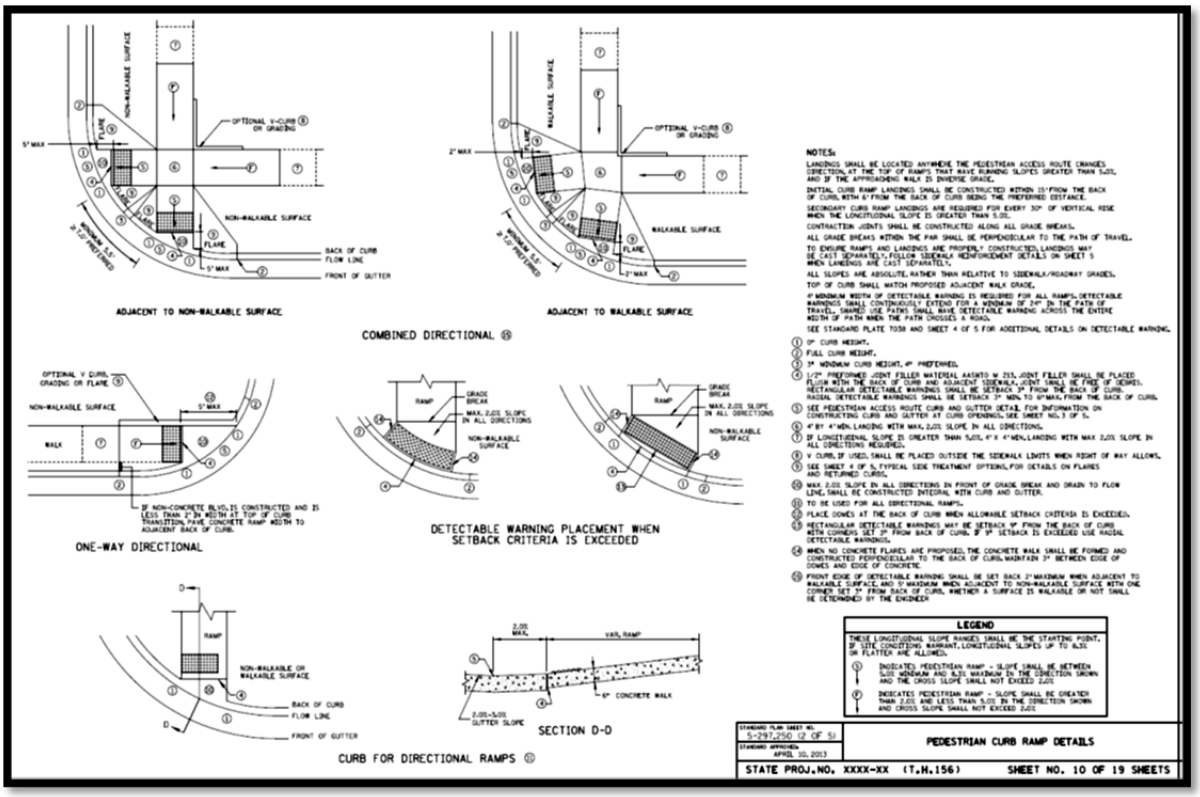
6.2.3.6 Pedestrian Crosswalk Details

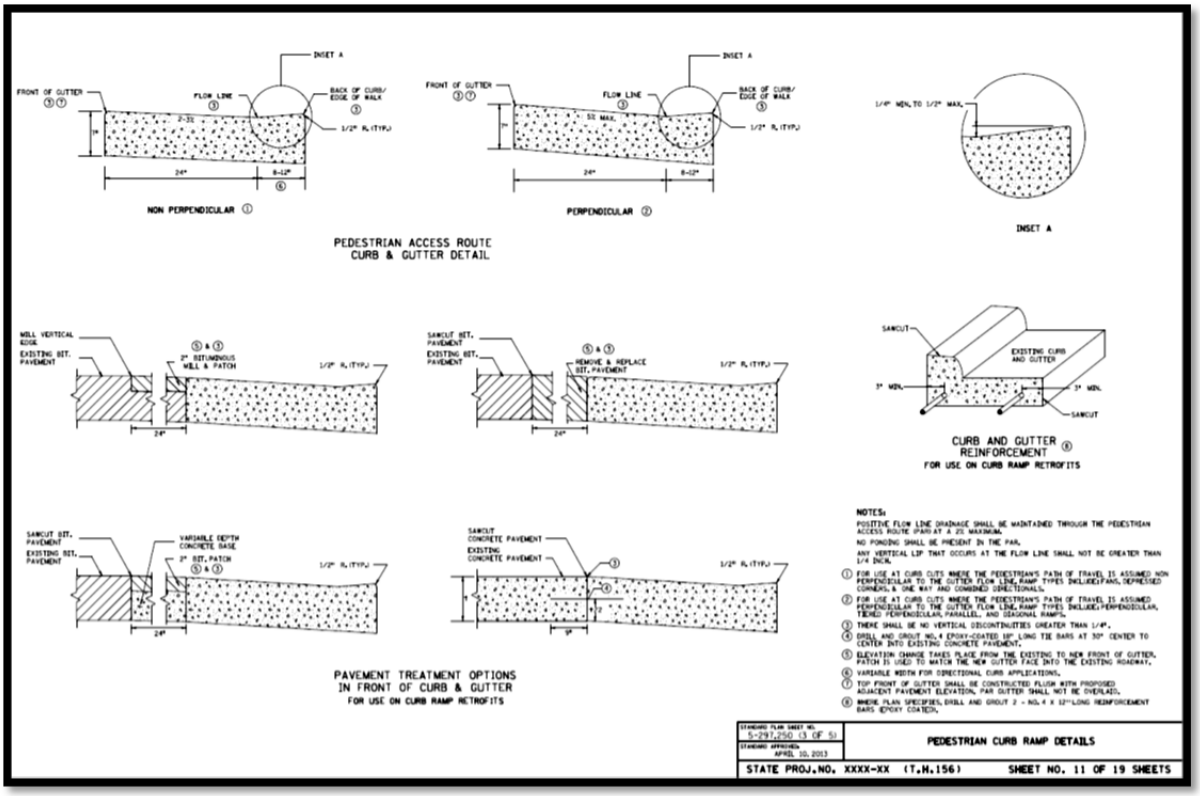


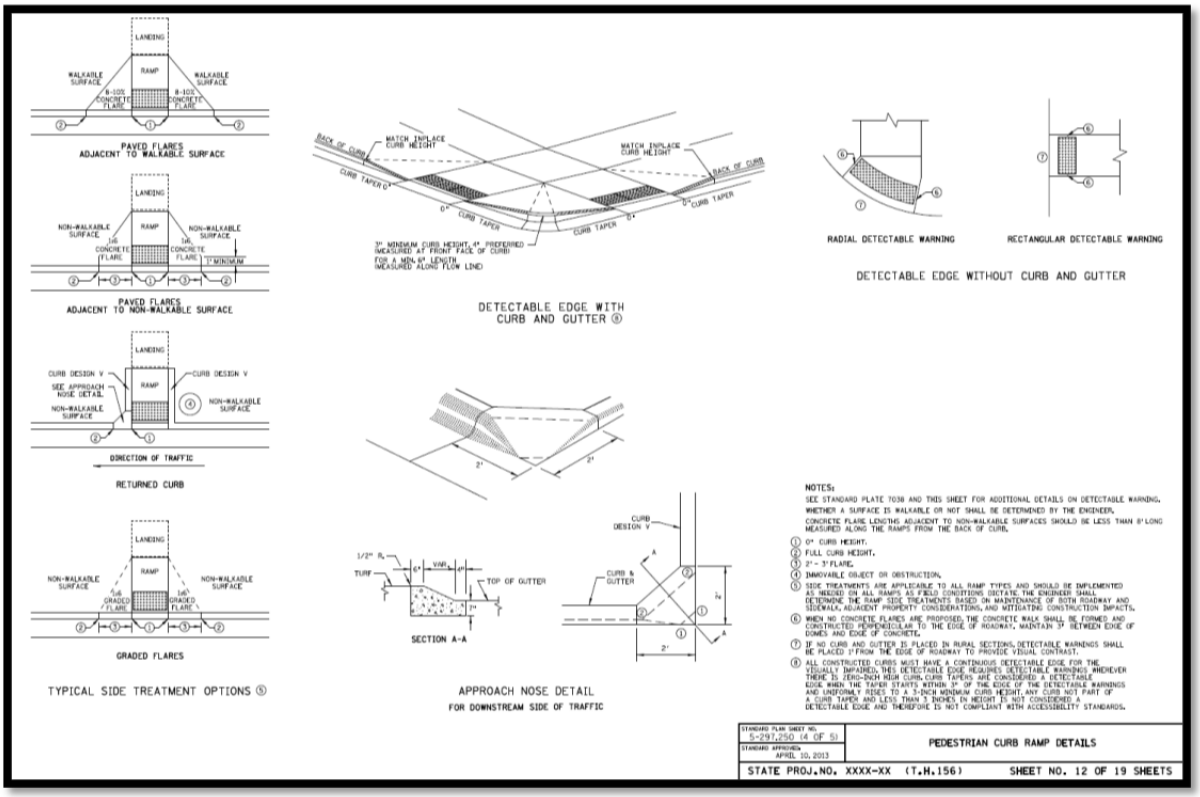
Refer to Chapter 12 for an 11” x 17” copy of the above plan sheet.

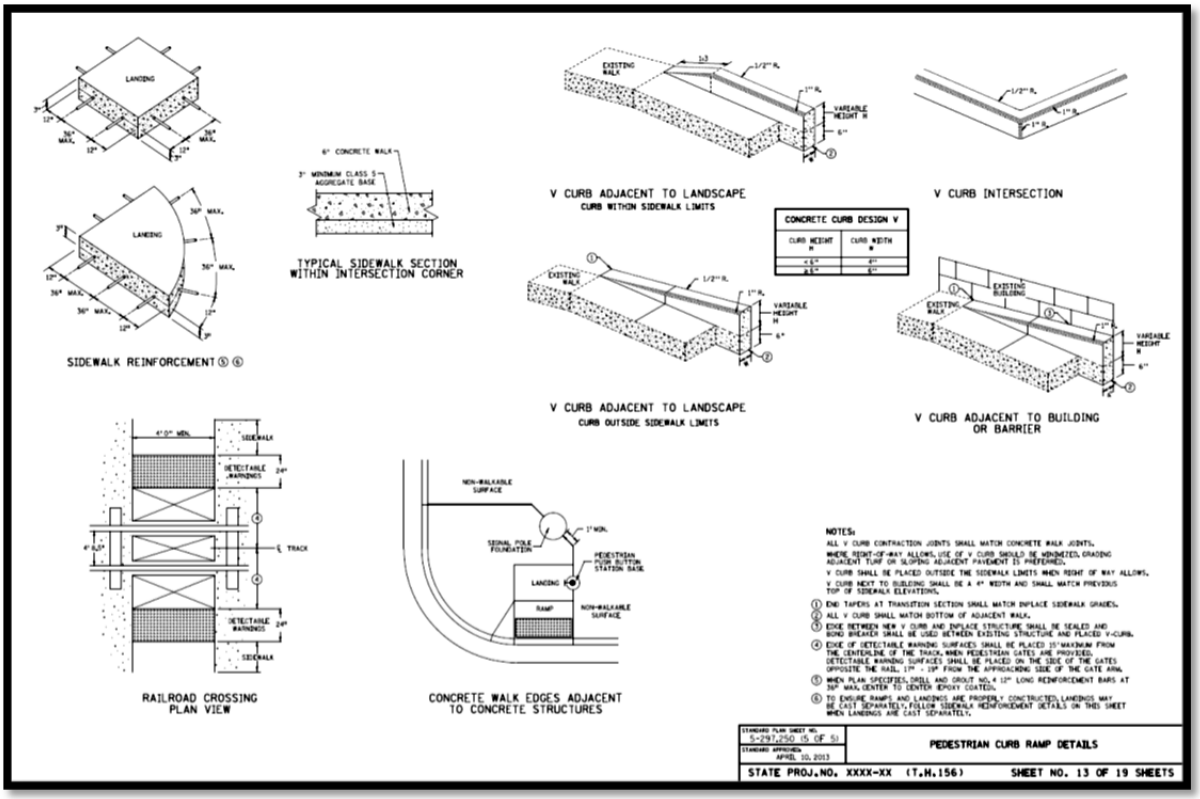
6.2.3.7 Pedestrian Curb Ramp Details (5 sheets)



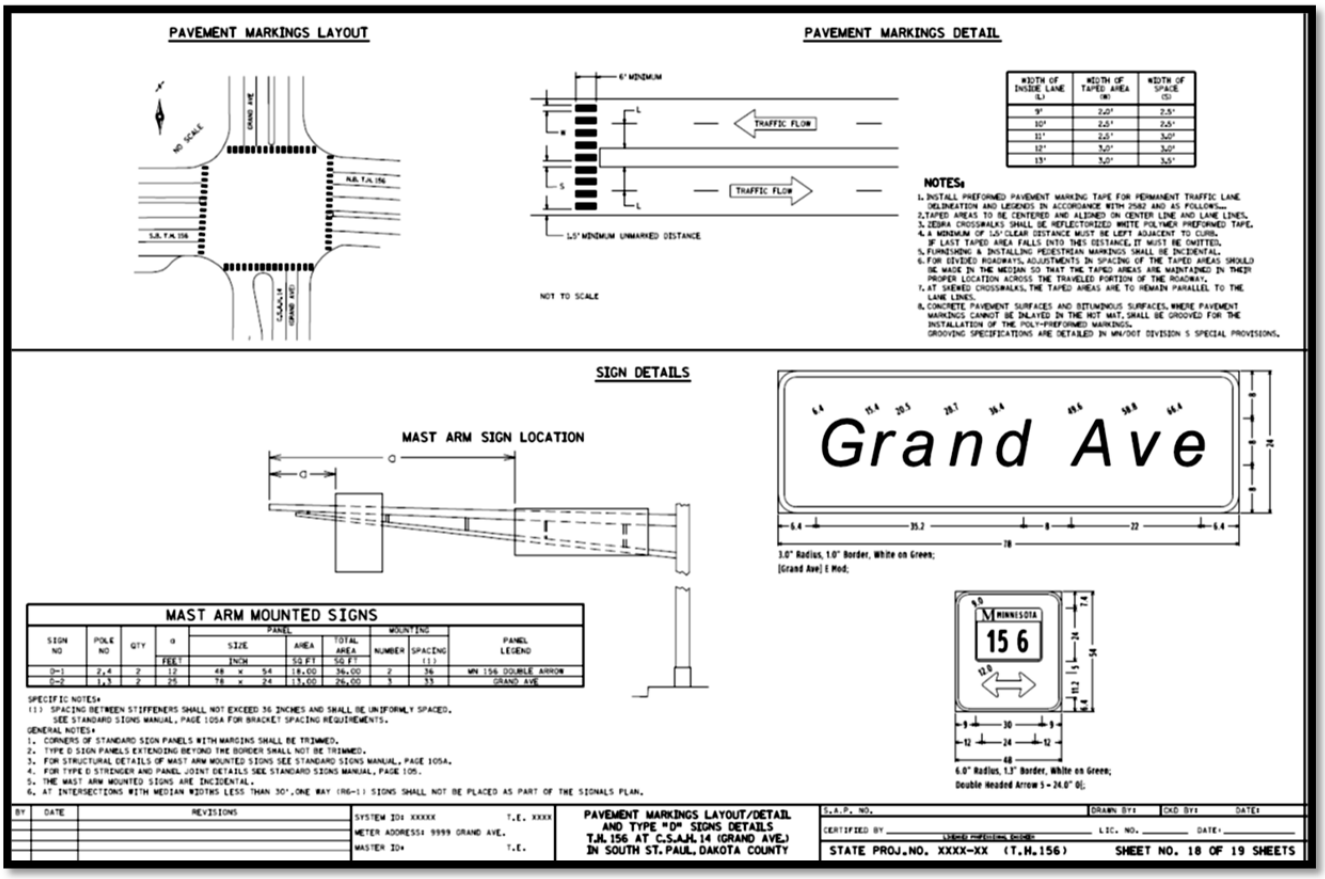



INSET A
FRONT OF GUTTER
FLOW LINE
BACK OF CURB/ EDGE OF WALK
1/2" R. (TYP.)
NON PERPENDICULAR ①
PERPENDICULAR ②
PEDESTRIAN ACCESS ROUTE
CURB & GUTTER DETAIL
1/4" MIN. TO 1/2" MAX.
INSET A
MILL VERTICAL EDGE
EXISTING BIT. PAVEMENT
2" BITUMINOUS MILL & PATCH
SAWCUT BIT. PAVEMENT
REMOVE & REPLACE BIT. PAVEMENT
SAWCUT
EXISTING CURB AND GUTTER
3" MIN.
CURB AND GUTTER REINFORCEMENT ⑧
FOR USE ON CURB RAMP RETROFITS
VARIABLE DEPTH CONCRETE BASE
2" BIT. PATCH
SAWCUT CONCRETE PAVEMENT
EXISTING CONCRETE PAVEMENT
PAVEMENT TREATMENT OPTIONS
IN FRONT OF CURB & GUTTER
FOR USE ON CURB RAMP RETROFITS
NOTES:
POSITIVE FLOW LINE DRAINAGE SHALL BE MAINTAINED THROUGH THE PEDESTRIAN ACCESS ROUTE (PAR) AT A 2% MAXIMUM.
NO PONDING SHALL BE PRESENT IN THE PAR.
ANY VERTICAL LIP THAT OCCURS AT THE FLOW LINE SHALL NOT BE GREATER THAN 1/4 INCH.
① FOR USE AT CURB CUTS WHERE THE PEDESTRIAN'S PATH OF TRAVEL IS ASSUMED NON PERPENDICULAR TO THE GUTTER FLOW LINE, RAMP TYPES INCLUDE:FLARS, DEPRESSED CORNERS, & ONE WAY AND COMBINED DIRECTIONALS.
② FOR USE AT CURB CUTS WHERE THE PEDESTRIAN'S PATH OF TRAVEL IS ASSUMED PERPENDICULAR TO THE GUTTER FLOW LINE, RAMP TYPES INCLUDE:PERPENDICULAR, TRENCH PERPENDICULAR, PARALLEL, AND DIAGONAL RAMPS.
③ THERE SHALL BE NO VERTICAL DISCONTINUITIES GREATER THAN 1/4".
④ DRILL AND GROUT NO.4 EPOXY-COATED 18" LONG TIE BARS AT 30" CENTER TO CENTER INTO EXISTING CONCRETE PAVEMENT.
⑤ ELEVATION CHANGE TAKES PLACE FROM THE EXISTING TO NEW FRONT OF GUTTER. PATCH IS USED TO MATCH THE NEW GUTTER FACE INTO THE EXISTING ROADWAY.
⑥ VARIABLE WIDTH FOR DIRECTIONAL CURB APPLICATIONS.
⑦ TOP FRONT OF GUTTER SHALL BE CONSTRUCTED FLUSH WITH PROPOSED ADJACENT PAVEMENT ELEVATION. PAR GUTTER SHALL NOT BE OVERLAID.
⑧ WHERE PLAN SPECIFIES, DRILL AND GROUT 2 - NO.4 X 12"-LONG REINFORCEMENT BARS (EPOXY COATED).
STANDARD PLAN SHEET NO. 5-297.250 (3 OF 5)
STANDARD APPROVED APRIL 10, 2013
PEDESTRIAN CURB RAMP DETAILS
STATE PROJ.NO. XXXX-XX (T.H.156) SHEET NO. 11 OF 19 SHEETS


LANDING
RAMP
WALKABLE SURFACE
8-10% CONCRETE FLARE
PAVED FLARES
ADJACENT TO WALKABLE SURFACE
NON-WALKABLE SURFACE
10% CONCRETE FLARE
1' MINIMUM
PAVED FLARES
ADJACENT TO NON-WALKABLE SURFACE
CURB DESIGN V
SEE APPROACH NOSE DETAIL
DIRECTION OF TRAFFIC
RETURNED CURB
GRADED FLARE
GRADED FLARES
TYPICAL SIDE TREATMENT OPTIONS ⑤
BACK OF CURB
MATCH INPLACE CURB HEIGHT
CURB TAPER
3" MINIMUM CURB HEIGHT, 4" PREFERRED (MEASURED AT FRONT FACE OF CURB)
FOR A MIN. 6" LENGTH (MEASURED ALONG FLOW LINE)
DETECTABLE EDGE WITH
CURB AND GUTTER ⑨
RADIAL DETECTABLE WARNING
RECTANGULAR DETECTABLE WARNING
DETECTABLE EDGE WITHOUT CURB AND GUTTER
1/2" R.
TURF
VAR.
TOP OF GUTTER
SECTION A-A
CURB DESIGN V
CURB & GUTTER
APPROACH NOSE DETAIL
FOR DOWNSTREAM SIDE OF TRAFFIC
NOTES:
SEE STANDARD PLATE 7038 AND THIS SHEET FOR ADDITIONAL DETAILS ON DETECTABLE WARNING.
WHETHER A SURFACE IS WALKABLE OR NOT SHALL BE DETERMINED BY THE ENGINEER.
CONCRETE FLARE LENGTHS ADJACENT TO NON-WALKABLE SURFACES SHOULD BE LESS THAN 8' LONG MEASURED ALONG THE RAMPS FROM THE BACK OF CURB.
① 0" CURB HEIGHT.
② FULL CURB HEIGHT.
③ 2' - 3' FLARE.
④ IMMOVABLE OBJECT OR OBSTRUCTION.
⑤ SIDE TREATMENTS ARE APPLICABLE TO ALL RAMP TYPES AND SHOULD BE IMPLEMENTED AS NEEDED ON ALL RAMPS AS FIELD CONDITIONS DICTATE. THE ENGINEER SHALL DETERMINE THE RAMP SIDE TREATMENTS BASED ON MAINTENANCE OF BOTH ROADWAY AND SIDEWALK, ADJACENT PROPERTY CONSIDERATIONS, AND MITIGATING CONSTRUCTION IMPACTS.
⑥ WHEN NO CONCRETE FLARES ARE PROPOSED, THE CONCRETE WALK SHALL BE FORMED AND CONSTRUCTED PERPENDICULAR TO THE EDGE OF ROADWAY, MAINTAIN 3" BETWEEN EDGE OF DOWEL AND EDGE OF CONCRETE.
⑦ IF NO CURB AND GUTTER IS PLACED IN RURAL SECTIONS, DETECTABLE WARNINGS SHALL BE PLACED 1' FROM THE EDGE OF ROADWAY TO PROVIDE VISUAL CONTRAST.
⑧ ALL CONSTRUCTED CURBS MUST HAVE A CONTINUOUS DETECTABLE EDGE FOR THE VISUALLY IMPAIRED. THIS DETECTABLE EDGE REQUIRES DETECTABLE WARNINGS WHEREVER THERE IS ZERO-INCH HIGH CURB. CURB TAPERS ARE CONSIDERED A DETECTABLE EDGE WHEN THE TAPER STARTS WITHIN 3" OF THE EDGE OF THE DETECTABLE WARNINGS AND UNIFORMLY RISES TO A 3-INCH MINIMUM CURB HEIGHT. ANY CURB NOT PART OF A CURB TAPER AND LESS THAN 3 INCHES IN HEIGHT IS NOT CONSIDERED A DETECTABLE EDGE AND THEREFORE IS NOT COMPLIANT WITH ACCESSIBILITY STANDARDS.
STANDARD PLAN SHEET NO. 5-297.250 (4 OF 5)
STANDARD APPROVED APRIL 10, 2013
PEDESTRIAN CURB RAMP DETAILS
STATE PROJ.NO. XXXX-XX (T.H.156) SHEET NO. 12 OF 19 SHEETS


LANDING
SIDEWALK REINFORCEMENT ⑤ ⑥
6" CONCRETE WALK
3" MINIMUM CLASS 5 AGGREGATE BASE
TYPICAL SIDEWALK SECTION WITHIN INTERSECTION CORNER
EXISTING WALK
VARIABLE HEIGHT H
V CURB ADJACENT TO LANDSCAPE
CURB WITHIN SIDEWALK LIMITS
V CURB INTERSECTION
CONCRETE CURB DESIGN V
CURB HEIGHT H
CURB WIDTH W
V CURB ADJACENT TO LANDSCAPE
CURB OUTSIDE SIDEWALK LIMITS
EXISTING BUILDING
V CURB ADJACENT TO BUILDING OR BARRIER
SIDEWALK
DETECTABLE WARNINGS
TRACK
RAILROAD CROSSING PLAN VIEW
NON-WALKABLE SURFACE
SIGNAL POLE FOUNDATION
PEDESTRIAN PUSH BUTTON STATION BASE
LANDING
RAMP
CONCRETE WALK EDGES ADJACENT TO CONCRETE STRUCTURES
NOTES:
ALL V CURB CONTRACTION JOINTS SHALL MATCH CONCRETE WALK JOINTS.
WHERE RIGHT-OF-WAY ALLOWS, USE OF V CURB SHOULD BE MINIMIZED. GRADING ADJACENT TURF OR SLOPING ADJACENT PAVEMENT IS PREFERRED.
V CURB SHALL BE PLACED OUTSIDE THE SIDEWALK LIMITS WHEN RIGHT OF WAY ALLOWS.
V CURB NEXT TO BUILDING SHALL BE A 4" WIDTH AND SHALL MATCH PREVIOUS TOP OF SIDEWALK ELEVATIONS.
① END TAPERS AT TRANSITION SECTION SHALL MATCH INPLACE SIDEWALK GRADES.
② ALL V CURB SHALL MATCH BOTTOM OF ADJACENT WALK.
③ EDGE BETWEEN NEW V CURB AND INPLACE STRUCTURE SHALL BE SEALED AND BOND BREAKER SHALL BE USED BETWEEN EXISTING STRUCTURE AND PLACED V-CURB.
④ EDGE OF DETECTABLE WARNING SURFACES SHALL BE PLACED 15" MAXIMUM FROM THE CENTERLINE OF THE TRACK. WHEN PEDESTRIAN GATES ARE PROVIDED, DETECTABLE WARNING SURFACES SHALL BE PLACED ON THE SIDE OF THE GATES OPPOSITE THE RAIL. 17" - 19" FROM THE APPROACHING SIDE OF THE GATE ARM.
⑤ WHEN PLAN SPECIFIES, DRILL AND GROUT NO. 4 12" LONG REINFORCEMENT BARS AT 36" MAX. CENTER TO CENTER EPOXY COATED.
⑥ TO ENSURE RAMPS AND LANDINGS ARE PROPERLY CONSTRUCTED, LANDINGS MAY BE CAST SEPARATELY. FOLLOW SIDEWALK REINFORCEMENT DETAILS ON THIS SHEET WHEN LANDINGS ARE CAST SEPARATELY.
STANDARD PLAN SHEET NO. 5-297.250 (5 OF 5)
STANDARD APPROVED APRIL 10, 2013
PEDESTRIAN CURB RAMP DETAILS
STATE PROJ.NO. XXXX-XX (T.H.156)
SHEET NO. 13 OF 19 SHEETS

6.2.4.1 Pavement Marking and Type D Signs



Refer to Chapter 12 for an 11” x 17” copy of the above plan sheet.

- These sheets should identify if pavement markings or signing are incidental to the pay item or not.
- Use SignCAD™ software with current approved Federal alphabet.
- The form on the following page is used by the Metro Division to request signing. Note that the current standard notes are shown within the signing request form.
- Identify what signing uses overlays as opposed to new signing.
- At intersections with median widths less than 30’, one way (R6-1) signs shall not be placed as part of the signal plans.

The diagram used for this pavement-marking layout is a reduced version of this intersection. Layout with the pavement markings is laid out to facilitate identifying approximate quantities.

- Within metric plans, note that the pavement markings portion of the sheet is in metric units while, out of necessity, the signing portion of the sheet is in English units and is so labeled.
- These sheets should identify if pavement markings or signing are incidental to the pay item or not.
- Do not use pavement markings across free right pedestrian movements.

Traffic control signal system Design – Signing Request
(Preliminary Intersection Layout(s) is Attached)

T.H. _____ at _____ S.P. _____ Letting Date: _____

Request to: _____ Request by: _____ Date: _____

TYPE "D" SIGNS								
SIGN PANEL	SIGNAL SYSTEM	POLE NO.	a (ft)	SIZE (IN)	MOUNTING BRACKET		AREA/SIGN (SQ FT)	NO. REQ.
					NO.	SPACING (1)		

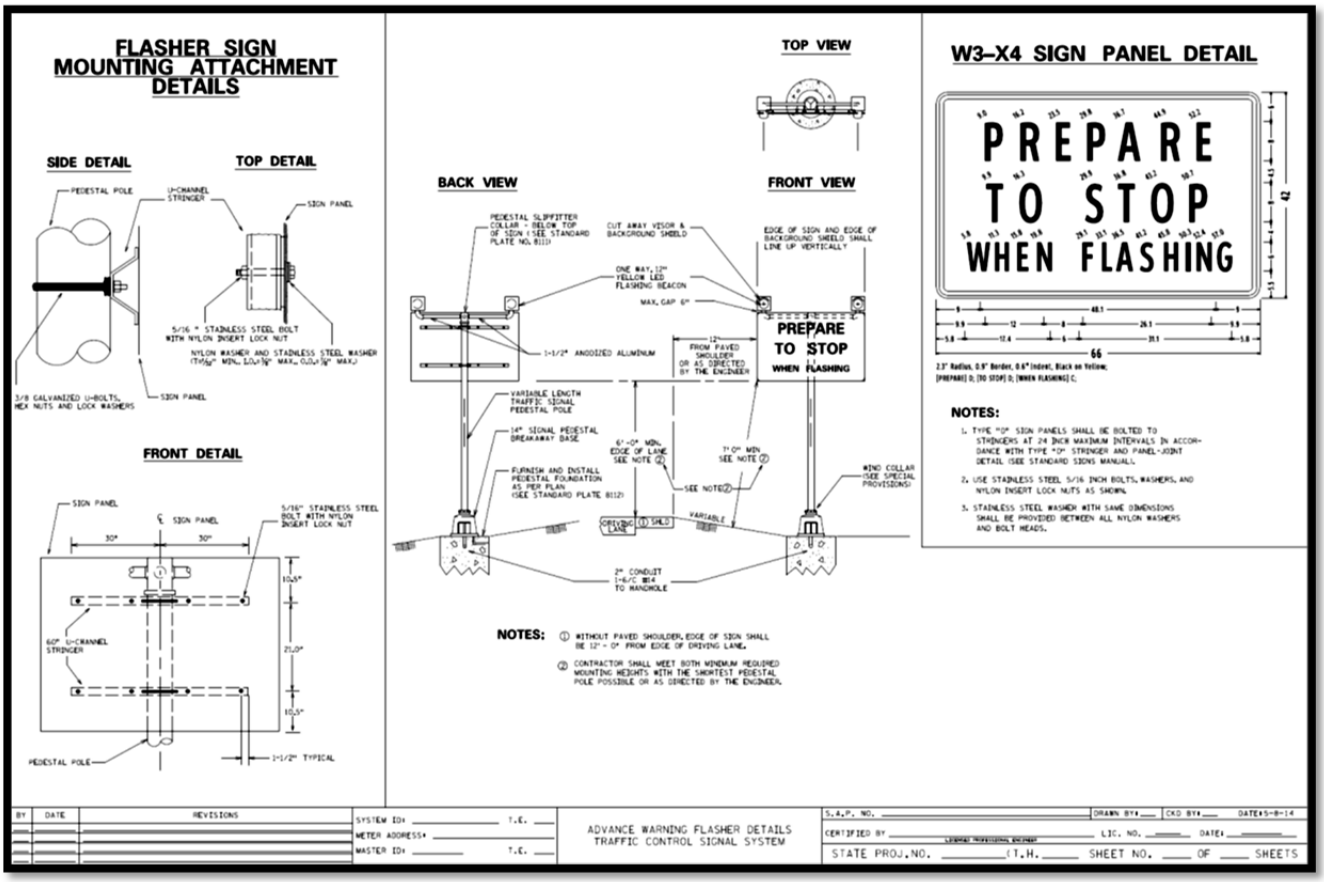
(1) SPACING BETWEEN STIFFNERS SHALL NOT EXCEED 36 INCHES AND SHALL BE UNIFORMLY SPACED. SEE SPECIAL PROVISIONS FOR BRACKET SPACING REQUIREMENTS.

OVERLAYS					
CODE NO.	QUAN.	SIZE (IN.)	AREA (SQ. FT.)	TOTAL (SQ. FT.)	LEGEND

NOTES:

- NO. OF POSTS SPACING CAN BE DETERMINED BY SIGNAL DESIGN PERSONNEL.
- ALL SIGN DIMENSIONS ARE ASSUMED TO BE IN ENGLISH UNITS UNLESS OTHERWISE INDICATED.
- PLEASE IDENTIFY IF THE FOLLOWING TYPICAL SIGN DETAIL NOTE ARE INAPPROPRIATE:
  1. CORNERS EXTENDING BEYOND THE BORDER SHALL NOT BE TRIMMED.
  2. SEE STANDARD SIGNS MANUAL FOR ARROW AND OVERLAY DETAILS.
  3. FOR STRUCTURAL DETAILS, TYPE "D" SIGNS, SEE STANARD SIGNS MANUAL, PAGES 105A AND 105B.
  4. FOR TYPE "D" STRINGER AND PANEL JOINT DETAIL, SE STANDARD SIGNS MANUAL.
  5. FURNISHING AND INSTALLING TYPE "D" AND TYPE "R" SIGNS SHALL BE INCIDENTAL TO THE TRAFFIC CONTROL SIGNAL SYSTEM(S).

6.2.4.2 Advance Warning Flasher Details



Note: This sheet is not included in the sample plan set.

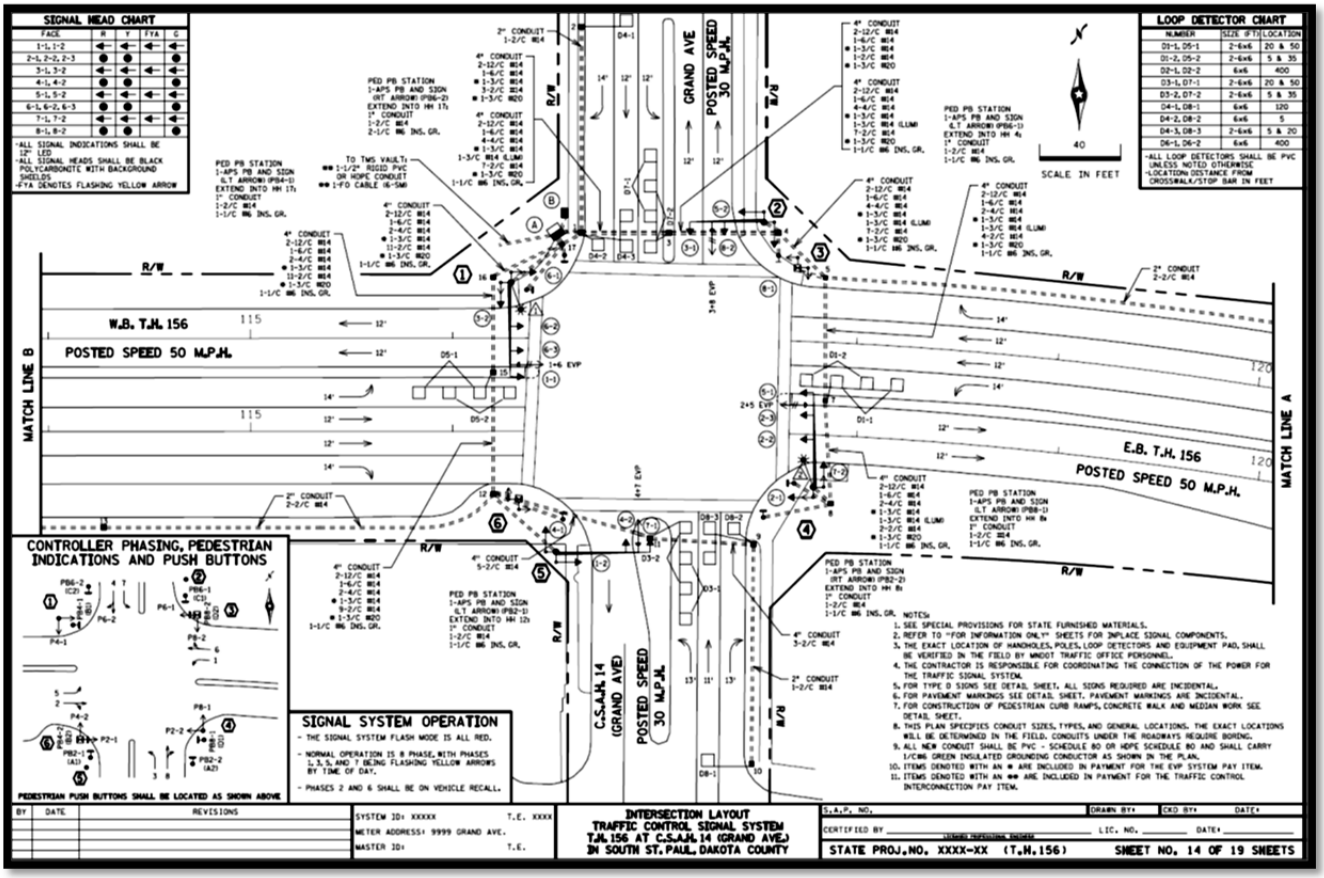
6.2.5 Intersection Layout

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

- Intersection geometrics (to scale) – lane widths shall be shown to facilitate staking
- All graphics depicting traffic control signal system components
- Controller phasing diagram
- Signal head chart
- Loop detectors table
- Signal pole notes
- APS
- Equipment pad notes
- Source of power notes
- Construction notes
- Plan sheet title and revision block (on all sheets)
- Traffic control signal system ID, meter address and TE number
- A bar scale
- A north arrow
- Posted speed limits
- Street names
- Metric logo (as necessary)
- DO NOT show utilities on the layout sheet, include additional sheet(s) for utilities.
- Newer signals show interconnect layout

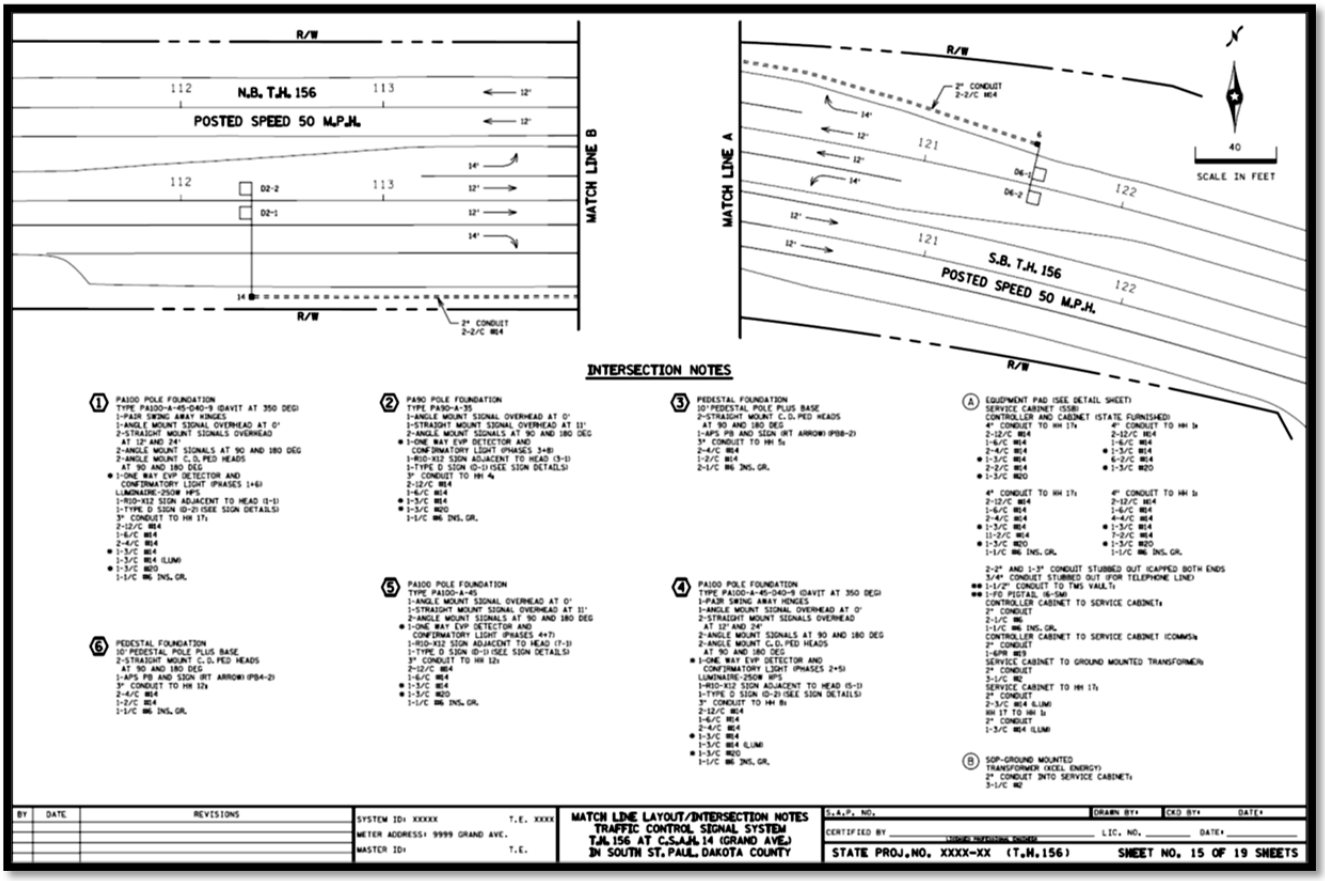
All items shall be properly labeled. The following sections define the numbering and labeling format for traffic signal plans.

6.2.5.1 Intersection Plan View

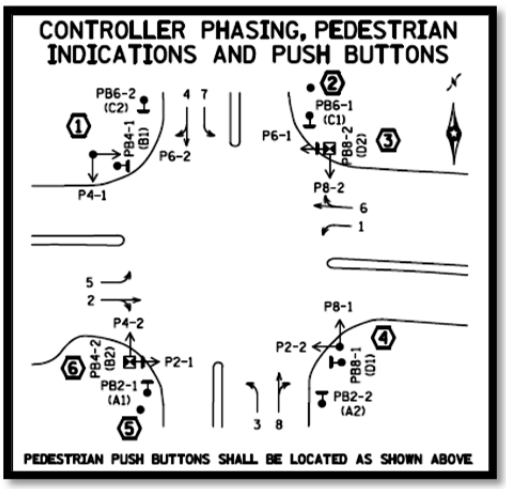


The mainline roadway (usually the trunk highway) shall be placed horizontal across the plan sheet with the North arrow up or to the right.

- All text on the layout and all other signal plan sheets, should be oriented to be read from the bottom or right sides of the plan sheet.
- Use match-line sheets to show all system components or equipment included within the system as a whole.
- The public right of way should be identified on the layout.
- As much information as reasonably possible (pole notes, etc.) should be provided on the first intersection plan view.
- Ped Push Buttons are normally included on the mainline.



6.2.5.2 Typical Controller Phasing Diagram



The mainline roadway should be assigned phases 2 and 6 with phase 2 going from left to right. The cross street roadway should be assigned phases 4 and 8 with phase 4 going from top to bottom. Left turn phases should be assigned as appropriate (see section 2.2.1).

If this is a revised traffic control signal system, the signal phasing should be brought to current standards whenever possible.

The layout of the phasing diagram should match the layout of the plan.

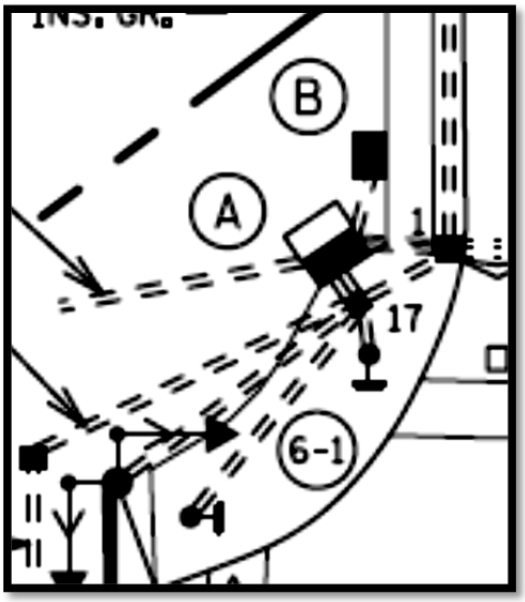
Flashing yellow arrow left turn phases should be labeled with the left turn phase first followed by the through phase (5,2 1,6 etc.) This phasing should be used on all new isolated or coordinated systems. If adding to an existing system, match the existing system phasing.

The standard phasing convention is phase 2 east when the trunk highway is east/west and phase 2 north when the trunk highway is north/south.

6.2.5.3 Equipment Pad and Source of Power Notes

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

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



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)
CONTROLLER AND CABINET (STATE FURNISHED)

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

4" CONDUIT TO HH 17:	4" CONDUIT TO HH 1:
2-12/C #14	2-12/C #14
1-6/C #14	1-6/C #14
2-4/C #14	4-4/C #14
* 1-3/C #14	* 1-3/C #14
11-2/C #14	7-2/C #14
* 1-3/C #20	* 1-3/C #20
1-1/C #6 INS. GR.	1-1/C #6 INS. GR.

2-2" AND 1-3" CONDUIT STUBBED OUT (CAPPED BOTH ENDS
3/4" CONDUIT STUBBED OUT (FOR TELEPHONE LINE)
** 1-1/2" CONDUIT TO TMS VAULT:
** 1-FO PIGTAIL (6-SM)
CONTROLLER CABINET TO SERVICE CABINET:
2" CONDUIT
2-1/C #6
1-1/C #6 INS. GR.
CONTROLLER CABINET TO SERVICE CABINET (COMMS):
2" CONDUIT
1-6PR #19
SERVICE CABINET TO GROUND MOUNTED TRANSFORMER:
2" CONDUIT
3-1/C #2
SERVICE CABINET TO HH 17:
2" CONDUIT
2-3/C #14 (LUM)
HH 17 TO HH 1:
2" CONDUIT
1-3/C #14 (LUM)

Note: 2/c#14 is loop lead-in cable.

6.2.5.4 Signal Base Notes


```
4  PA100 POLE FOUNDATION
   TYPE PA100-A-45-D40-9 (DAVIT AT 350 DEG)
   1-PAIR SWING AWAY HINGES
   1-ANGLE MOUNT SIGNAL OVERHEAD AT 0'
   2-STRAIGHT MOUNT SIGNALS OVERHEAD
    AT 12' AND 24'
   2-ANGLE MOUNT SIGNALS AT 90 AND 180 DEG
   2-ANGLE MOUNT C.D.PED HEADS
    AT 90 AND 180 DEG
 * 1-ONE WAY EVP DETECTOR AND
    CONFIRMATORY LIGHT (PHASES 2+5)
   LUMINAIRE-250W HPS
   1-R10-X12 SIGN ADJACENT TO HEAD (5-1)
   1-TYPE D SIGN (D-2) (SEE SIGN DETAILS)
   3" CONDUIT TO HH 8:
   2-12/C #14
   1-6/C #14
   2-4/C #14
 * 1-3/C #14
   1-3/C #14 (LUM)
 * 1-3/C #20
   1-1/C #6 INS. GR.
```

The pole note lists the foundation, pole, mast arm and everything that goes on it (signs, heads, hinges, etc) or in it (conductors). Refer to the checklist in chapter 5 for further information.

Number, in a hexagon, the signal bases clockwise with respect to the controller cabinet 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.

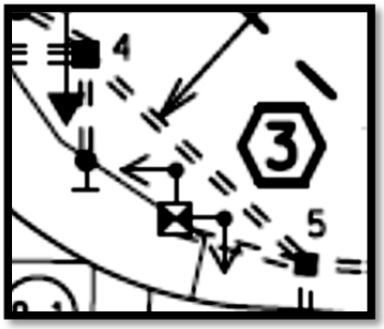
The following is a typical pole note (from above) that calls out one way mounts for mounting vehicle and pedestrian signal indications on a vertical pole shaft of a mast arm pole standard. The picture on the right shows a one-way signal mount. In Chapter 12, there is a standard detail of the one-way mount.

```
2-ANGLE MOUNT SIGNALS AT 90 AND 180 DEG
2-ANGLE MOUNT C.D.PED IND
```

6.2.5.5 Handhole Labeling

Number the handholes clockwise with respect to the controller cabinet with Number 1 being adjacent to or near the controller cabinet. It is not necessary to use H.H.

In the figure at the right, the handholes are shown as the solid black square and labeled 4 and 5. A solid (filled) symbol identifies new equipment and an open symbol identifies in-place equipment.

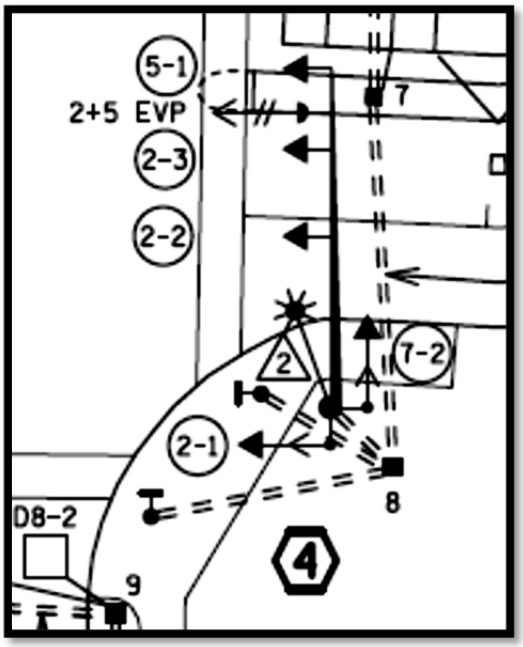


6.2.5.6 Vehicle Signal Head Labeling

Number, in a circle, vehicle signal head per phase from right to left as you approach the intersection. Signal head should be numbered with the controller phase first followed by the head number (for example 2-1, 2-2, etc.).

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

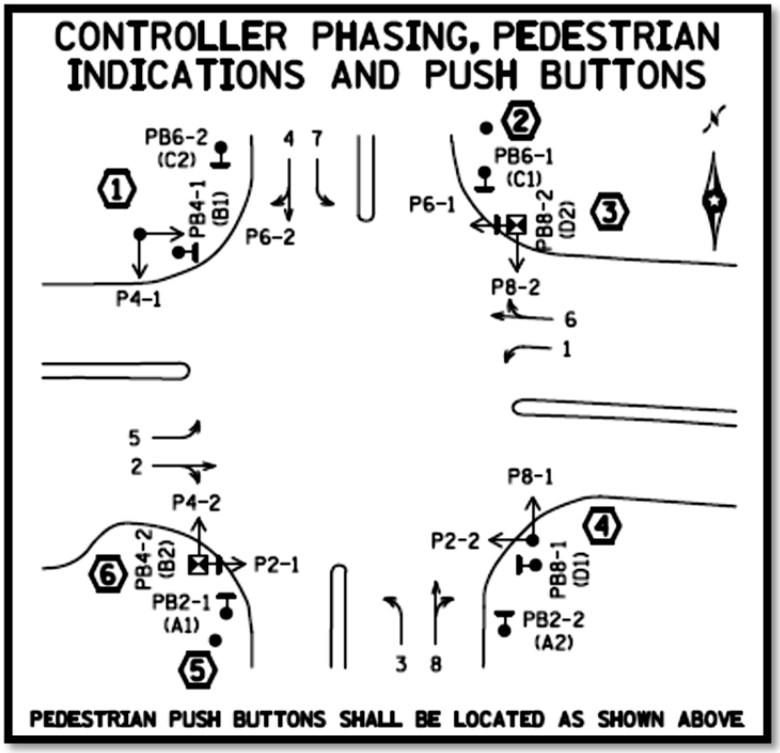
Fya left turn signal heads should be labeled with the left turn phase (1, 2, 5, 7).

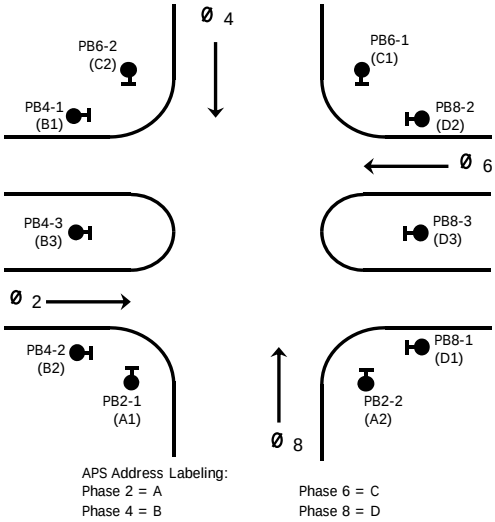


6.2.5.7 Pedestrian Signal Head and Push Button Labeling

Number pedestrian signal heads per phase 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. These numbers should be proceeded by a P and the controller phase number (for example P4-1, P4-2, etc.).

Number pedestrian push button per phase with Number 1 being the first on the right and Numbers 2 on the opposite corner. If there is a median PB, this will be labeled with Number 3 (see the figure below).

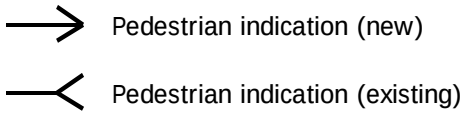


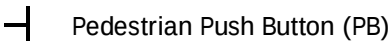


APS Pedestrian push button requires an address label as shown in the figure to the left. The address will be based on the PB phase number. Phase 2 is labeled with an A, Phase 4 is labeled with a B, Phase 6 is labeled with a C and Phase 8 is labeled with a D.

The APS address will be placed in parenthesis "()". The letter will be followed with a number. Use number 1 to match the PB label 1. The opposite corner will be number 2. If there is a median, the number will be 3. It can also be noted that the PB number and the APS address number will be the same. For example, PB4-1 = B1, PB4-2 = B2 and PB4-3 = B3.

The following symbols are used to identify new and existing pedestrian signals (see the Technical Manual for more symbols):



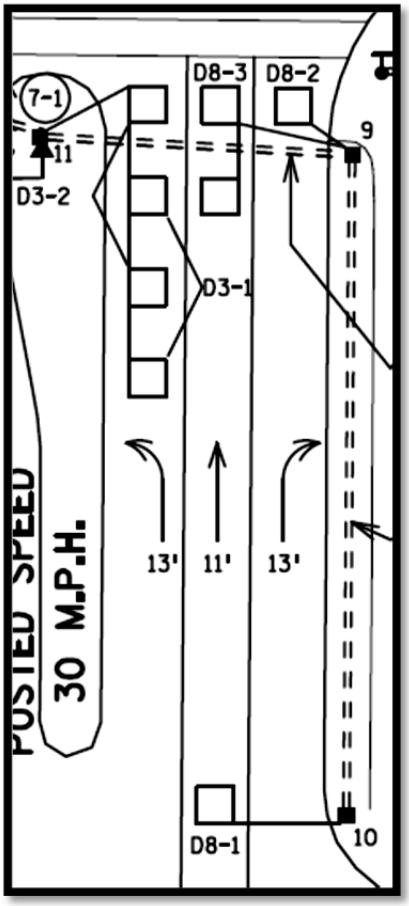


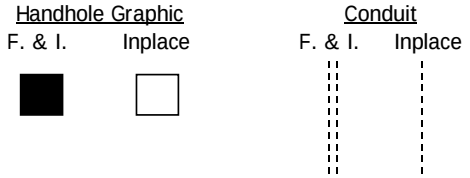
6.2.5.8 Loop Detector Labeling

Number detectors per phase 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. At the stop line, Number 3 would be in the right lane with Number 4 to the left as you proceed to the intersection. These numbers should be proceeded by a D and the controller phase number (an example D8-1, D8-2, etc.). Also, if there is more than one detector in the left lane, Number 1 would be the first detector as you approach the intersection and Number 2 the second.

For the flashing yellow arrow movement, the detector should be labeled with the protected phase number (proceeded by a D) followed by the detector number. An example would be D3-1, D3-2, etc).

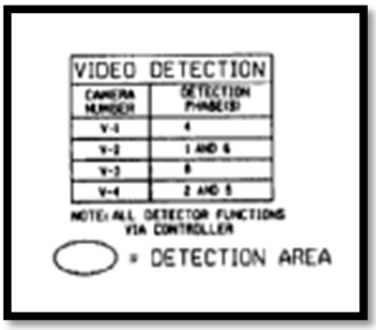
A solid line indicates a new detector and a dashed line indicates an existing detector.

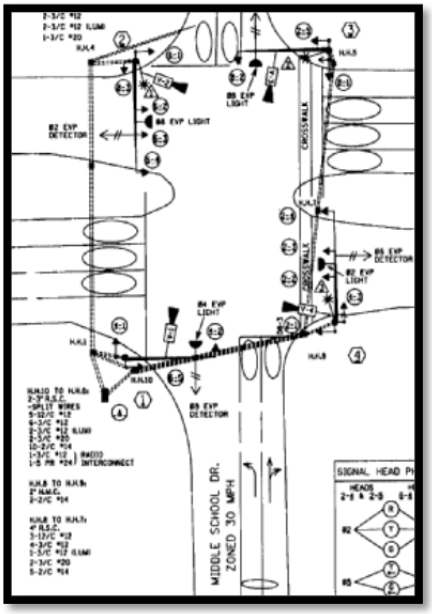




Note: For a complete listing of symbols used, refer to the Technical Manual

Other types of detection technology that may be used include microwave and video imaging technology. Refer to Chapter 3 for details on additional detector technologies. An example of an intersection layout using video detection is shown below.





6.2.5.9 Luminaire Labeling

Number in a triangle the luminaries clockwise with respect to the controller cabinet with Number 1 being the first luminaire on a signal base.

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

6.2.5.10 Signal Head Chart

The signal head chart identifies the face configuration for the signals shown on the plan sheet. The head identification number (i.e, 1-1, refers to the circled signal head shown on the intersection plan sheet.

If protected/permissive five section signal heads are used, and the plan should include one of the "Signal Head Phasing" graphics shown below.

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

SIGNAL HEAD 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

Example Chart with Flashing Yellow Arrow

6.2.5.11 Loop Detectors Table

The loop detector table identifies the size and location of the detectors shown on the plan sheet. The detector number (i.e., D1-1), refers to the detector shown on the intersection plan sheet. For most MnDOT projects, a "Function" column is not required. Some agencies may, however, require this column. See chapter 3 for details on detector functions.

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	6x6	5
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

6.2.5.12 Preemption

This may include emergency vehicle preemption (EVP), railroad preemption, or other forms of preemption.

The designer and project manager should work with the local agency to determine needs.

Railroad

The designer should work with the railroad company and the MnDOT Office of Freight and Commercial Vehicle Operations.

EVP

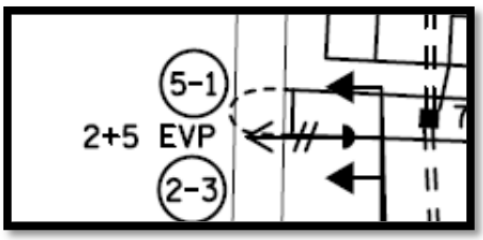
All new systems must get wired for EVP.

All revised systems should get wired for EVP if not already wired whenever possible.

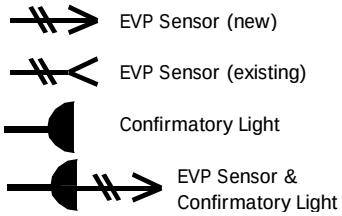
The standard note should be included to identify the EVP hub configuration and location [6' (2 m)].

Each approach which has an EVP detector must have a confirmatory light for that approach on the far mast arm.

EVP sensor can be placed anywhere on the traffic control signal system if it helps reception from the emergency vehicle such as accommodating a curve in the road.



The following symbols are used to identify new and existing EVP:



6.2.5.13 Construction Notes

The construction notes are used to describe circumstances that pertain to the signal design.

NOTES:

1. SEE SPECIAL PROVISIONS FOR STATE FURNISHED MATERIALS.
2. REFER TO "FOR INFORMATION ONLY" SHEETS FOR INPLACE SIGNAL COMPONENTS.
3. THE EXACT LOCATION OF HANDHOLES, POLES, LOOP DETECTORS AND EQUIPMENT PAD, SHALL BE VERIFIED IN THE FIELD BY MNDOT TRAFFIC OFFICE PERSONNEL.
4. THE CONTRACTOR IS RESPONSIBLE FOR COORDINATING THE CONNECTION OF THE POWER FOR THE TRAFFIC SIGNAL SYSTEM.
5. FOR TYPE D SIGNS SEE DETAIL SHEET. ALL SIGNS REQUIRED ARE INCIDENTAL.
6. FOR PAVEMENT MARKINGS SEE DETAIL SHEET. PAVEMENT MARKINGS ARE INCIDENTAL.
7. FOR CONSTRUCTION OF PEDESTRIAN CURB RAMPS, CONCRETE WALK AND MEDIAN WORK SEE DETAIL SHEET.
8. THIS PLAN SPECIFIES CONDUIT SIZES, TYPES, AND GENERAL LOCATIONS. THE EXACT LOCATIONS WILL BE DETERMINED IN THE FIELD. CONDUITS UNDER THE ROADWAYS REQUIRE BORING.
9. ALL NEW CONDUIT SHALL BE PVC - SCHEDULE 80 OR HDPE SCHEDULE 80 AND SHALL CARRY 1/C#6 GREEN INSULATED GROUNDING CONDUCTOR AS SHOWN IN THE PLAN.
10. ITEMS DENOTED WITH AN * ARE INCLUDED IN PAYMENT FOR THE EVP SYSTEM PAY ITEM.
11. ITEMS DENOTED WITH AN ** ARE INCLUDED IN PAYMENT FOR THE TRAFFIC CONTROL INTERCONNECTION PAY ITEM.

6.2.5.14 Title Block

The title block is required on all sheets. For the intersection layout sheet the traffic control signal system ID, meter address and TE number should be included. If the system is interconnected and this system has the master, then the title block should also indicate the master controller ID number and TE number.

The location identified should list intersections from west to east or south to north.

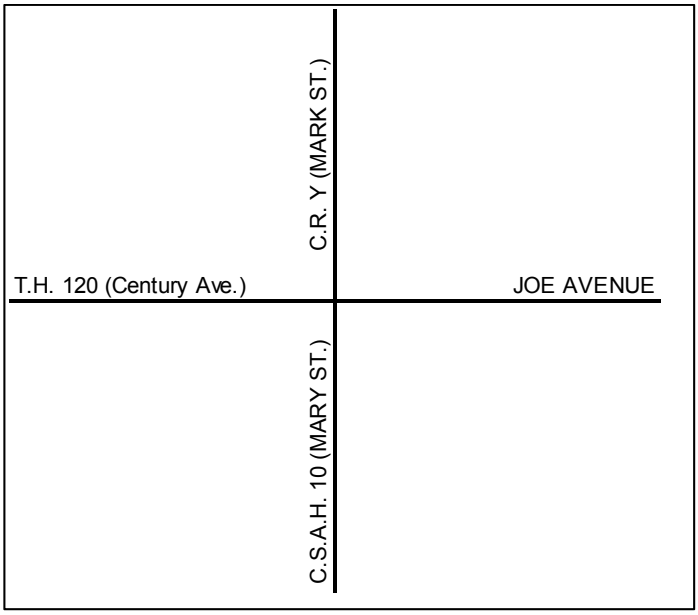
SYSTEM ID: XXXXX T.E. XXXX METER ADDRESS: 9999 GRAND AVE. MASTER ID: T.E.	INTERSECTION LAYOUT TRAFFIC CONTROL SIGNAL SYSTEM T.H. 156 AT C.S.A.H. 14 (GRAND AVE.) IN SOUTH ST. PAUL, DAKOTA COUNTY	S.A.P. NO. DRAWN BY: CKD BY: DATE: CERTIFIED BY _____ LICENSED PROFESSIONAL ENGINEER LIC. NO. _____ DATE: _____ STATE PROJ.NO. XXXX-XX (T.H.156) SHEET NO. 14 OF 19 SHEETS

All applicable State Aid numbers are listed on each plan sheet.

When identifying the intersection location, the T.H. designation always appears first followed by the cross street (i.e., T.H. XX AT CROSS STREET). When an intersection includes multiple route (street names), then the order of significance is T.H. route, C.S.A.H route, C.R. then local street. The intersection at the left would be identified as follows:

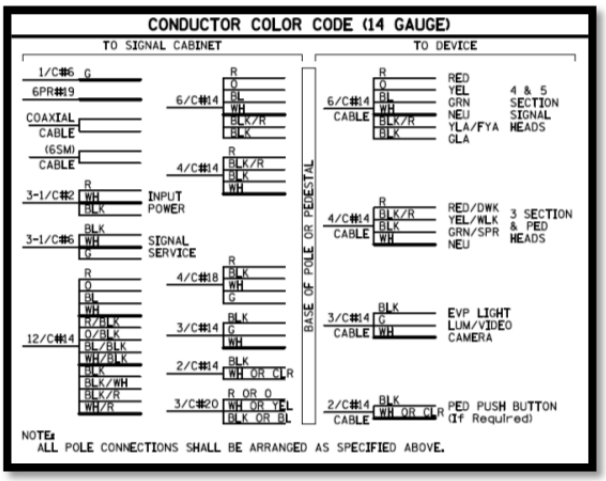
T.H. 120 (CENTURY AVE.)/JOE AVE.

AT C.S.A.H 10 (MARY ST.)/C.R. Y (MARK ST.)

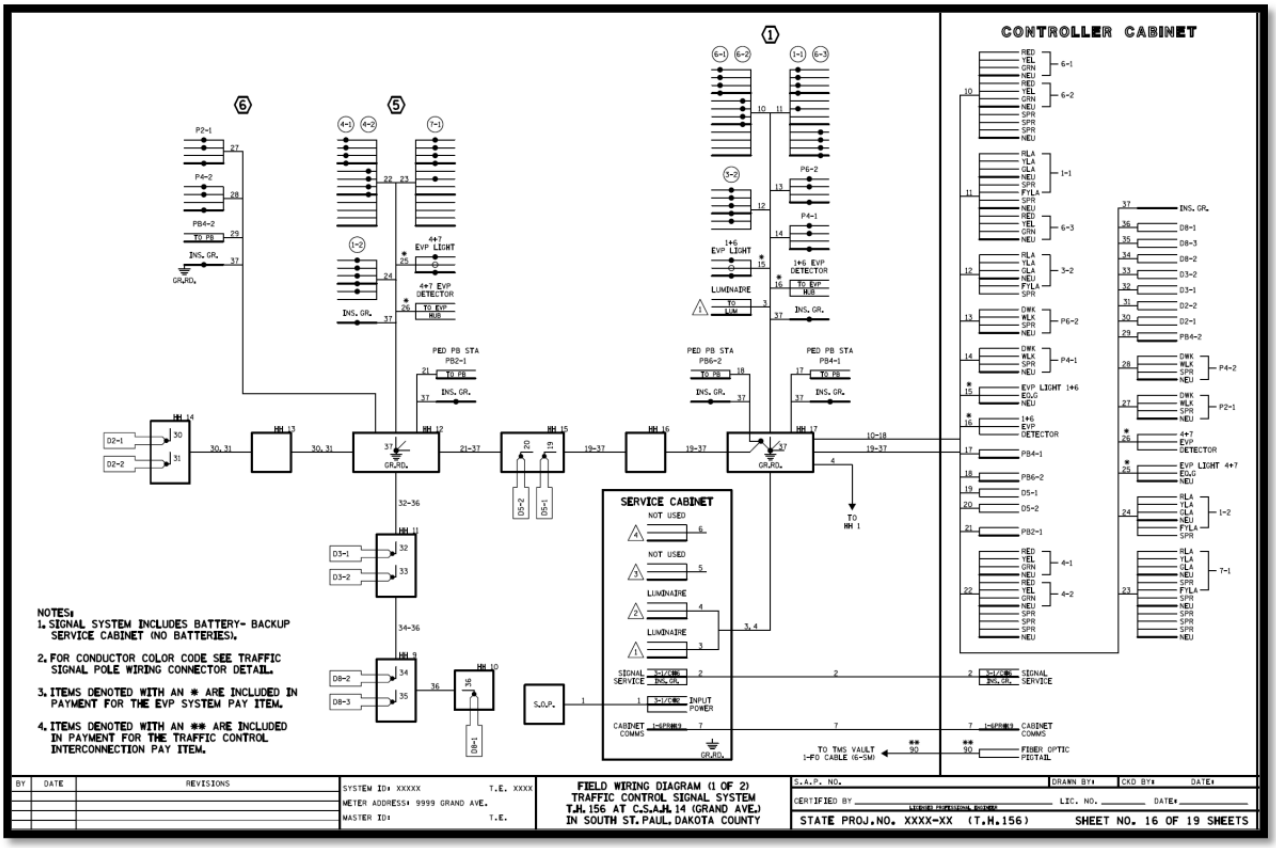


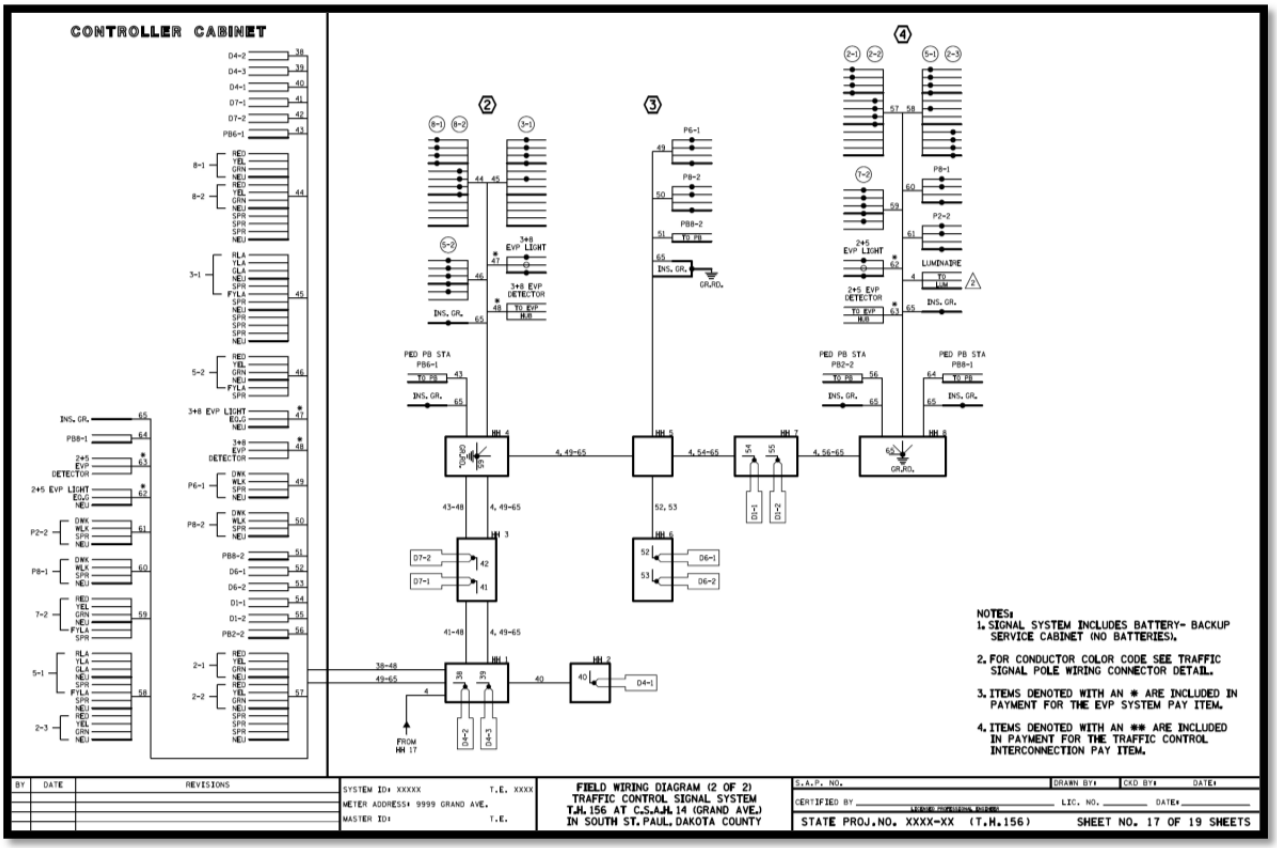
6.2.6 Field Wiring

The field wiring diagram is used to describe how the actual field wiring shall be placed (also see section 5C-2). Some of the issues associated with this sheet include:



- The diagram is not to scale and is a schematic of the electrical distribution including the terminations of the conductors in the pole/pedestal bases (terminal blocks).
- Lay out the wiring diagram in the same orientation as the intersection layout. If the traffic control signal system is laid out such that the cable runs leave the cabinet and "wrap around" the intersection, then show the cabinet in the center of the wiring diagram with cables leaving both sides of the cabinet.
- The sheet could include a conductor color coding block but is normally on the pole base connector detail
- The sheet shall include a title block.
- A key for revisions shall be included as necessary. The components of this should be remove/dispose, furnish & install, and/or new cables.
- The wiring diagram should show all electrical elements included with system (including cameras, signs, free standing luminaries, etc.).
- Cables to start at number 7. Service cabinet details have 1-6 reserved (power feeds and luminaires).
- Neutrals are never to be shared.
- All conduits with 120 volts shall have 1/c #6 insulated green ground wire.
- 15' ground rods will be placed in hand holes nearest all signal pole. A ground rod id not needed at a HH next to a pedestal pole since there is a ground rod in the pedestal foundation. The 1/c #6 Green should go in and out of the pedestal if it needs to go on to another pole. (see the sample plan)


CONTROLLER CABINET
SERVICE CABINET
NOTES:
1. SIGNAL SYSTEM INCLUDES BATTERY- BACKUP SERVICE CABINET (NO BATTERIES).
2. FOR CONDUCTOR COLOR CODE SEE TRAFFIC SIGNAL POLE WIRING CONNECTOR DETAIL.
3. ITEMS DENOTED WITH AN * ARE INCLUDED IN PAYMENT FOR THE EVP SYSTEM PAY ITEM.
4. ITEMS DENOTED WITH AN ** ARE INCLUDED IN PAYMENT FOR THE TRAFFIC CONTROL INTERCONNECTION PAY ITEM.
FIELD WIRING DIAGRAM (1 OF 2)
TRAFFIC CONTROL SIGNAL SYSTEM
T.H. 156 AT C.S.A.H. 14 (GRAND AVE.)
IN SOUTH ST. PAUL, DAKOTA COUNTY
STATE PROJ.NO. XXXX-XX (T.H.156)
SHEET NO. 16 OF 19 SHEETS


CONTROLLER CABINET
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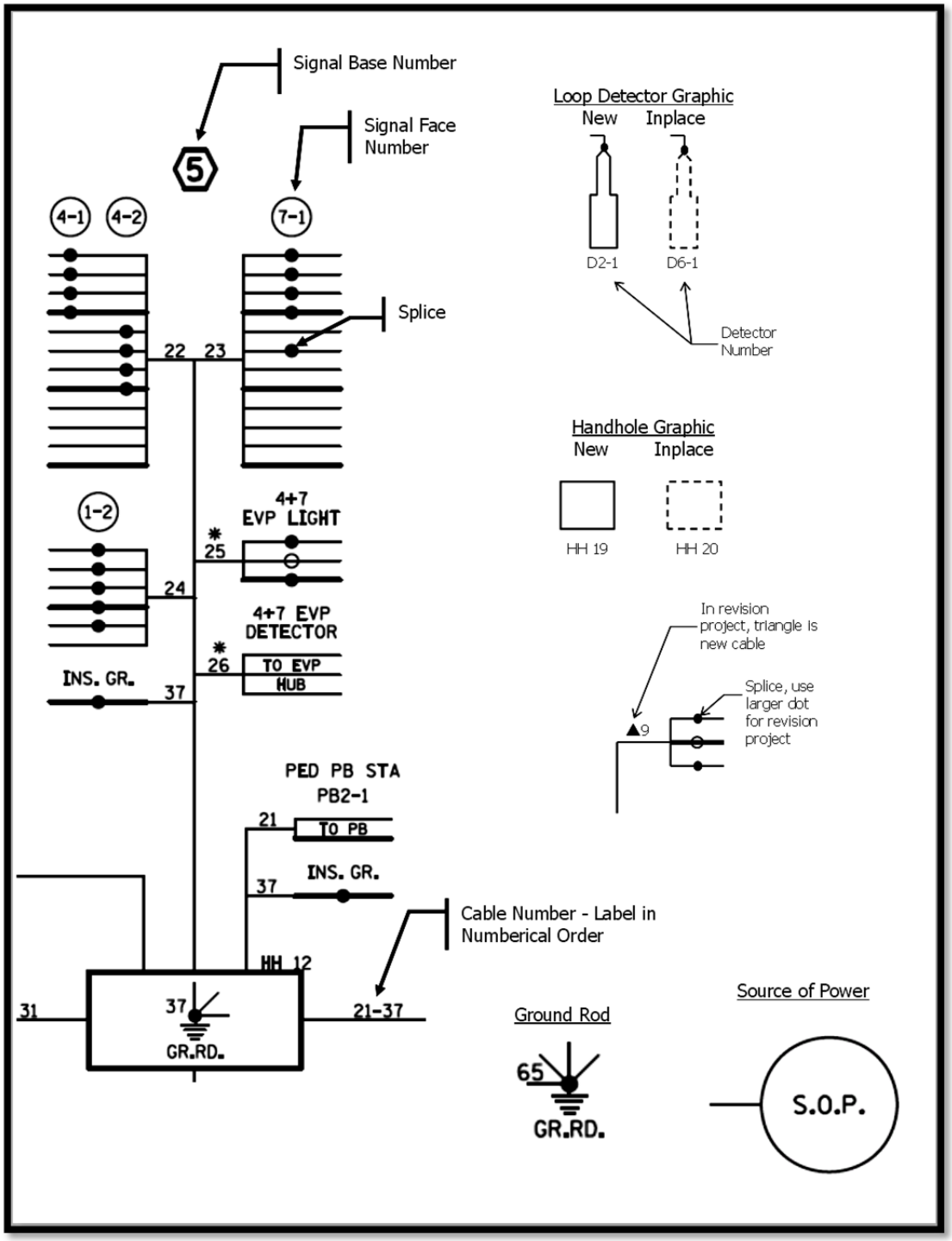
3. ITEMS DENOTED WITH AN * ARE INCLUDED IN PAYMENT FOR THE EVP SYSTEM PAY ITEM.
4. ITEMS DENOTED WITH AN ** ARE INCLUDED IN PAYMENT FOR THE TRAFFIC CONTROL INTERCONNECTION PAY ITEM.
FIELD WIRING DIAGRAM (2 OF 2)
TRAFFIC CONTROL SIGNAL SYSTEM
T.H. 156 AT C.S.A.H. 14 (GRAND AVE.)
IN SOUTH ST. PAUL, DAKOTA COUNTY
STATE PROJ.NO. XXXX-XX (T.H.156)
SHEET NO. 17 OF 19 SHEETS

Some of the graphics used on the Field Wiring diagram are shown below. Also, see the standard symbols from the Technical Manual on the following three pages.



TRAFFIC SIGNAL SYMBOLS AND ABBREVIATIONS
7/2005 (PAGE 1 OF 2)

LAYOUT + MATCH LINES ITEMS

ADVANCE WARNING FLASHER F&I
ADVANCE WARNING FLASHER INPL.
CONDUIT F&I
CONDUIT INPL.
DIRECT BURIED POWER CABLE F&I
DIRECT BURIED POWER CABLE INPL.
DIRECT BURIED INTERCONNECT CABLE F&I
DIRECT BURIED INTERCONNECT CABLE INPL.
CONFIRMATORY LIGHT F&I
CONFIRMATORY LIGHT INPL.
EVP DETECTOR F&I
EVP DETECTOR INPL.
EVP DETECTOR & CONFIRMATORY LIGHT F&I
EVP DETECTOR & CONFIRMATORY LIGHT INPL.
DOWN GUY FOR WOOD POLE
FLASHING BEACON F&I
FLASHING BEACON INPL.
HANDHOLE F&I
HANDHOLE INPL.
JUNCTION BOX F&I
JUNCTION BOX INPL.
LOOP DETECTOR F&I
LOOP DETECTOR INPL.
MAST ARM LUMINAIRE F&I
MAST ARM LUMINAIRE INPL.
MAST ARM WITH POLE F&I
MAST ARM WITH POLE INPL.
PAD F&I (SPECIFY EQUIPMENT)
PAD INPL. (SPECIFY EQUIPMENT)
PEDESTRIAN INDICATION F&I
PEDESTRIAN INDICATION INPL.
PEDESTRIAN PUSH BUTTON ON SIGNAL SUPPORT F&I
PEDESTRIAN PUSH BUTTON ON SIGNAL SUPPORT INPL.
PEDESTRIAN PUSH BUTTON STATION F&I
PEDESTRIAN PUSH BUTTON STATION INPL.
POLE F&I (SPECIFY TYPE)
POLE INPL. (SPECIFY TYPE)
POLE MOUNTED CABINET F&I
POLE MOUNTED CABINET INPL.

LAYOUT + MATCH LINES ITEMS

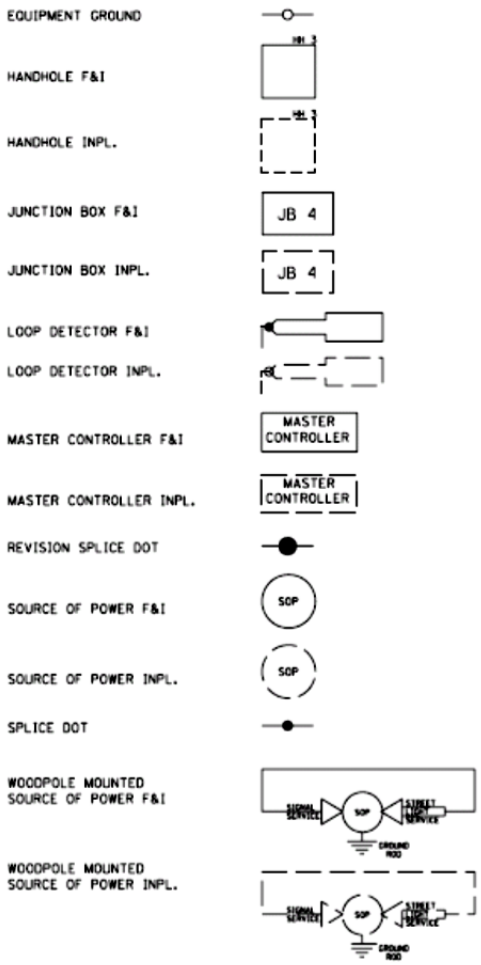
SIGNAL FACE F&I
SIGNAL FACE INPL.
SIGNAL FACE WITH BACKGROUND SHIELD F&I
SIGNAL FACE WITH BACKGROUND SHIELD INPL.
SIGNAL CONTROLLER AND OR EQUIPMENT PAD LABEL F&I
SIGNAL CONTROLLER AND OR EQUIPMENT PAD LABEL INPL.
SOURCE OF POWER LABEL F&I
SOURCE OF POWER LABEL INPL.
TRAFFIC SIGNAL PEDESTAL F&I
TRAFFIC SIGNAL PEDESTAL INPL.
VIDEO DETECTION
MICROWAVE DETECTION
SONIC DETECTION

COMMON ITEMS

GROUND ROD F&I
GROUND ROD INPL.
LUMINAIRE NUMBER F&I
LUMINAIRE NUMBER INPL.
SIGNAL BASE NUMBER F&I
SIGNAL BASE NUMBER INPL.
SIGNAL FACE NUMBER F&I
SIGNAL FACE NUMBER INPL.

TRAFFIC SIGNAL SYMBOLS AND ABBREVIATIONS
7/2005 (PAGE 2 OF 2)

WIRING DIAGRAM ITEMS



ABBREVIATIONS

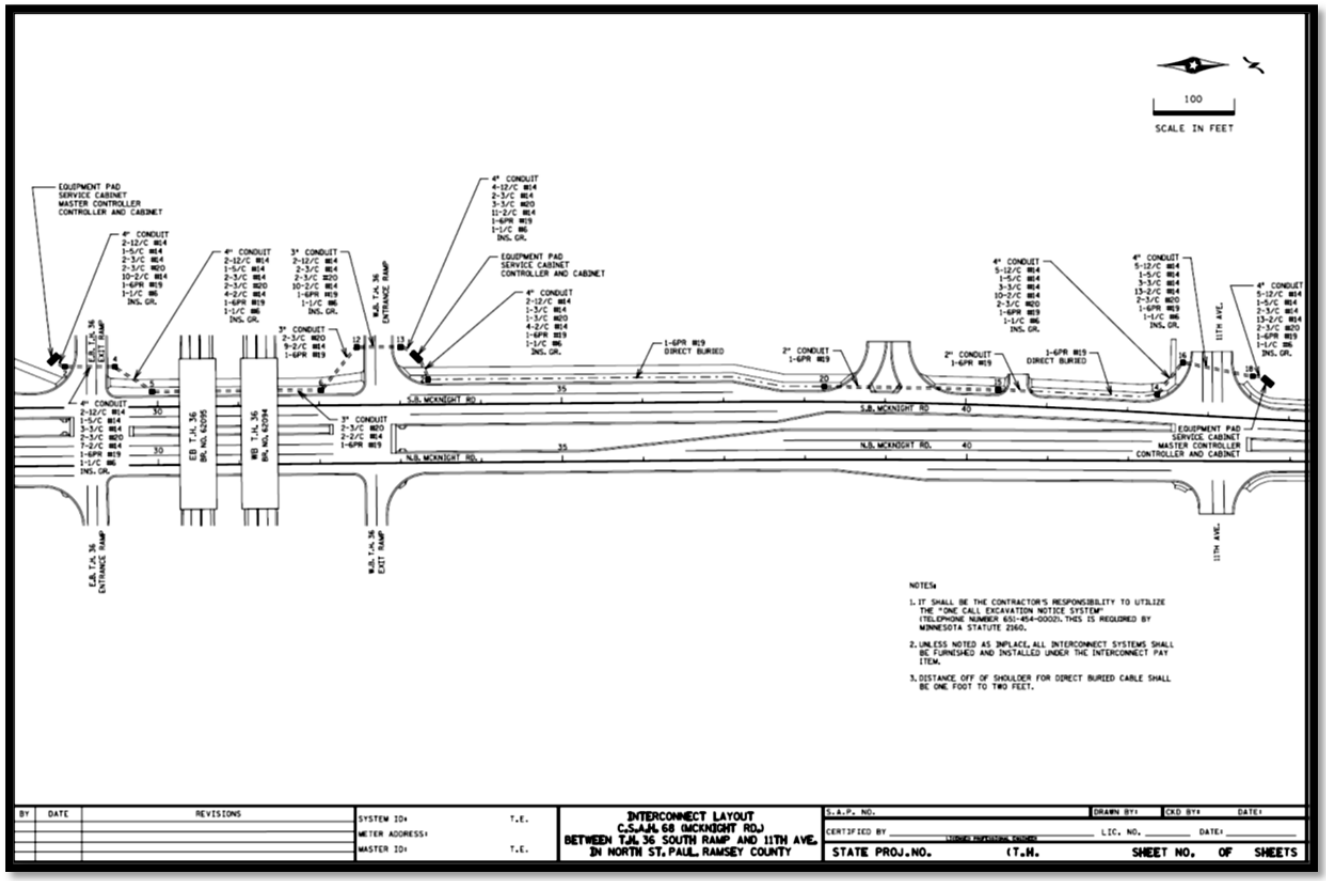
AWF	ADVANCE WARNING FLASHER
BL	BLUE
BL/BLK	BLUE WITH BLACK TRACER
BLK	BLACK
BLK/WH	BLACK WITH WHITE TRACER
CH. SW.	CHECK SWITCH
CLR	CLEAR
D2-1 (e.g.)	DETECTOR (PHASE 2, NO. 1)
DWK	DON'T WALK
EQ.G	EQUIPMENT GROUND
EVP	EMERGENCY VEHICLE PRE-EMPTION
F&I	FURNISH AND INSTALL
FL	FLASH/FLASHING
G	GREEN
G/BLK	GREEN WITH BLACK TRACER
GLTA	GREEN LEFT TURN ARROW
GRN	GREEN
GR. RD.	GROUND ROD
GRTA	GREEN RIGHT TURN ARROW
GTHA	GREEN THRU ARROW
HH	HANDHOLE
HPS	HIGH PRESSURE SODIUM
IMC	INTERMEDIATE METAL CONDUIT
INP	INPLACE
INS. GR.	INSULATED GROUND
JB	JUNCTION BOX
LED	LIGHT EMITTING DIODE
LHT	LIGHT
LUM	LUMINAIRE
NEU	NEUTRAL
NMC	NONMETALLIC CONDUIT
O	ORANGE
O/BLK	ORANGE WITH BLACK TRACER
P1-1 (e.g.)	PEDESTRIAN INDICATION (PHASE 1, NO. 1)
PB	PUSH BUTTON
PB2-1 (e.g.)	PUSH BUTTON (PHASE 2, NO. 1)
PEC	PHOTOELECTRIC CELL
PED	PEDESTRIAN
R	RED
R&S	REMOVE AND SALVAGE
R/BLK	RED WITH BLACK TRACER
RLTA	RED LEFT TURN ARROW
RSC	RIGID STEEL CONDUIT
SOP	SOURCE OF POWER
SPR	SPARE
ST LHT	STREET LIGHT
STA	STATION
SW	SWITCH
SWD	SWITCHED
TDW	TELEPHONE DROP WIRE
WH	WHITE
WH/BLK	WHITE WITH BLACK TRACER
WLK	WALK
YEL	YELLOW
YLTA	YELLOW LEFT TURN ARROW
YRTA	YELLOW RIGHT TURN ARROW

6.2.7 Traffic Control Interconnect Layout

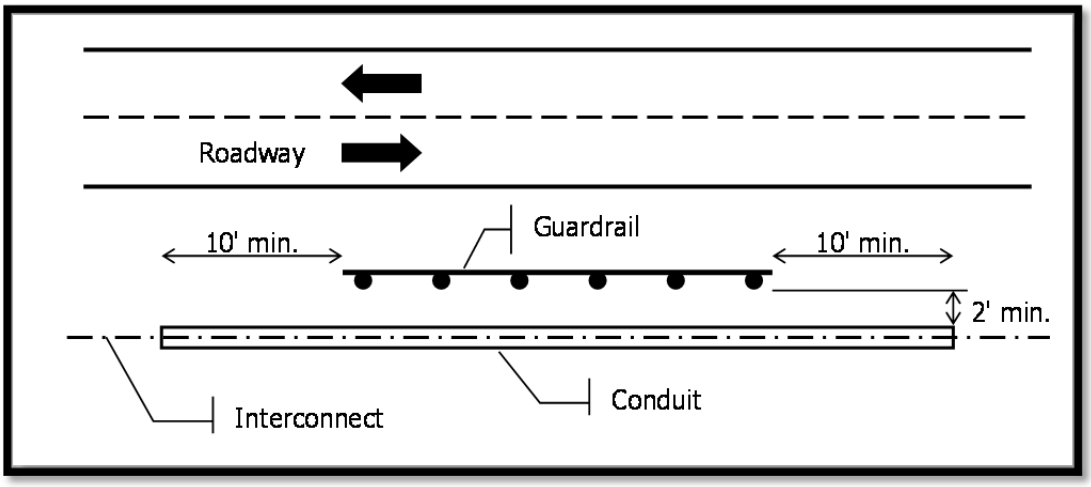
This sheet details the layout of the traffic control interconnect layout(s). Some of the issues associated with this sheet include:

- It shall be at a 1:100 (1:1000 Metric) scale
- Include a north arrow
- Include a scale graphic
- Include general notes

Work for the interconnect system which falls within the limits of the traffic control signal system layout should be shown on the traffic control signal system layout but should be identified clearly that such work is to be bid as part of the interconnect system.



The plan should identify all guardrails in the area. All interconnect near guardrail shall be placed in conduit. The conduit shall extend a minimum of ten feet beyond the end of the guardrail. Two feet (0.6 m) is the minimum clearance from the interconnect to the guardrail to which it is attached (see the figure below).



Show this detail on interconnect sheet if guardrail exists.

6.2.7.1 Fiber Optic Interconnect

The use of fiber optic cable for traffic signal interconnect can and should be considered. Fiber optic cable comes with benefits over standard copper cable, but these benefits can be offset by other factors. An agency must decide if the use of fiber will benefit them now and in the future. A sample special provisions and fiber wiring diagram are included in the Appendix. These samples highlight considerations of using fiber optic cable. Advanced fiber optics courses are offered, and highly recommended, for those who foresee or plan on using fiber optic cable.

6.2.8 Utilities

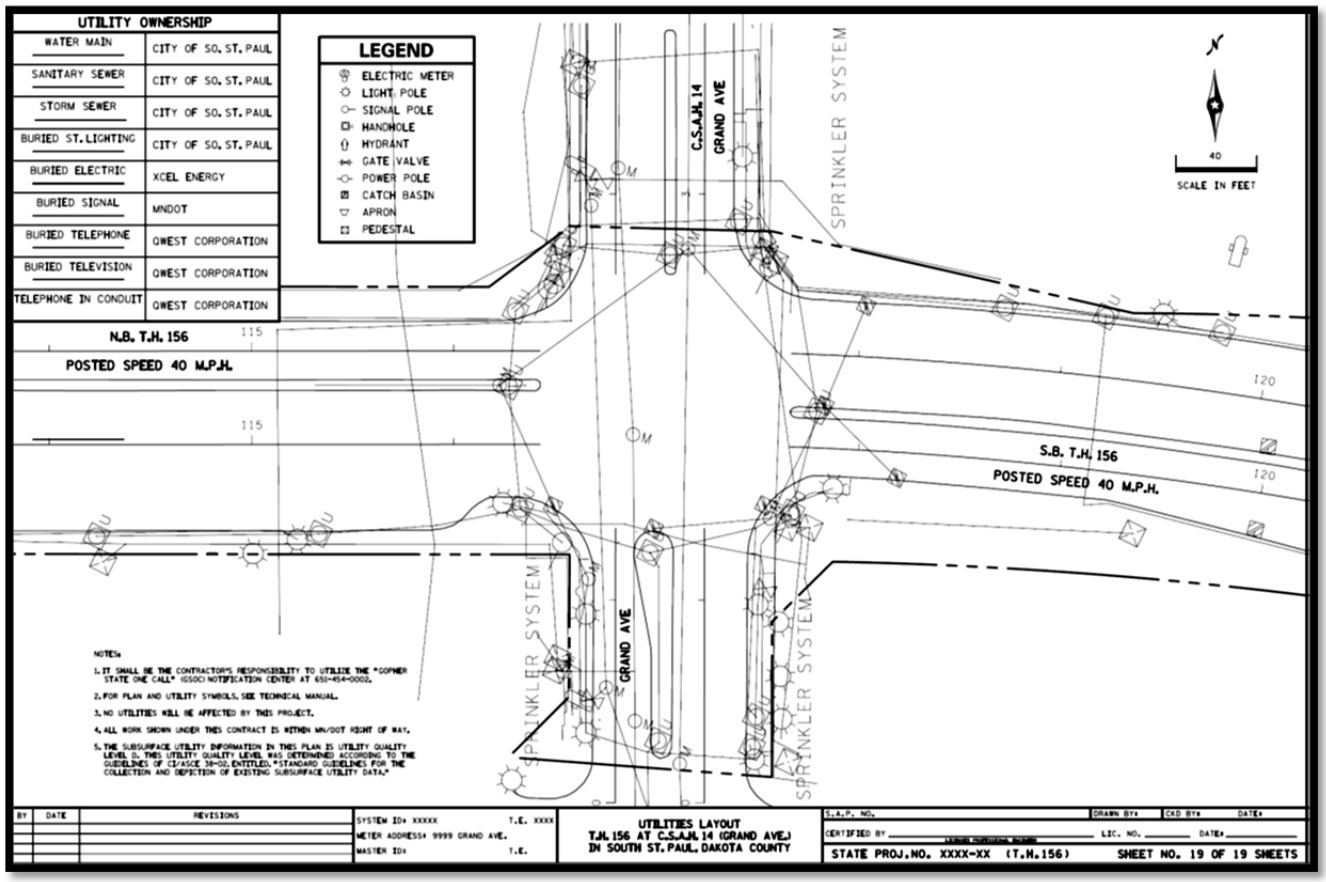
This sheet details the intersection utilities. Some of the issues associated with this sheet are:

- It shall include a utility table or graphic, but must show an ownership summary.
- It shall include a north arrow and scale.
- Include general notes.
- It shall be oriented in the same manner as the traffic control signal system layout.

Utility Plan Sheet Standard Notes

Notes:

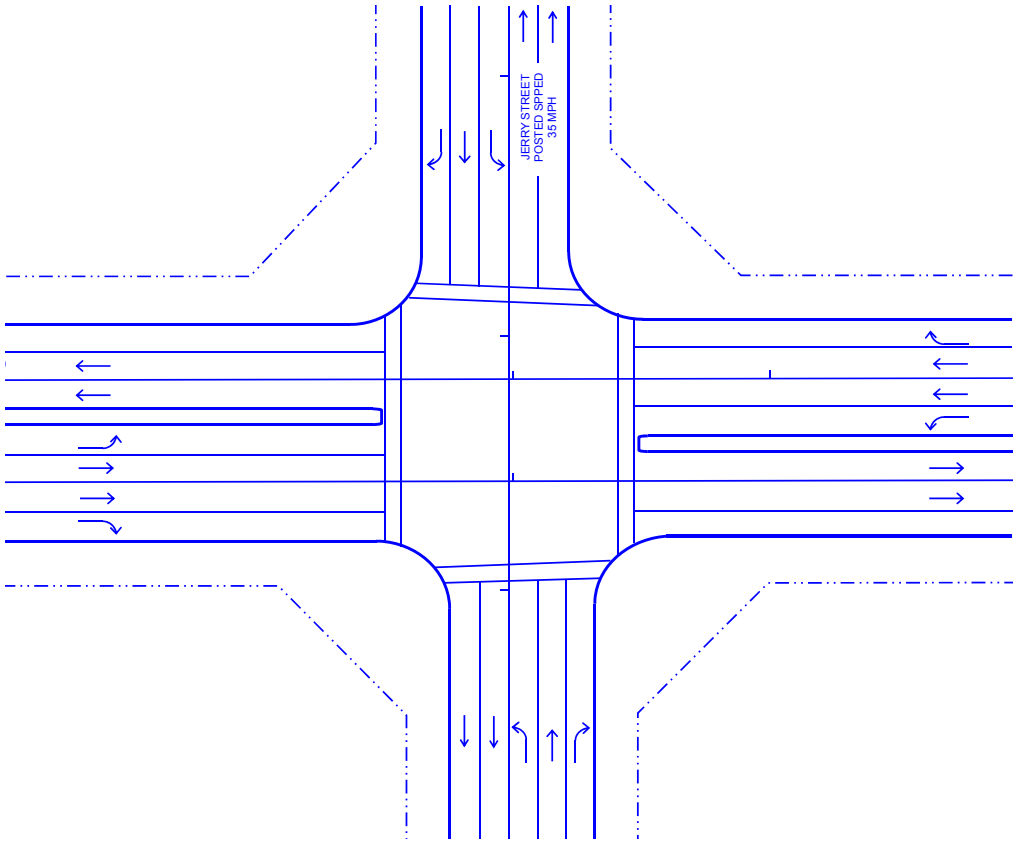
1. It shall be the contractors responsibility to utilize the "One Call Excavation Notice System" (Ph: 651-454-0002) required by Minnesota Statute 216D.
2. For plan and utilities symbols see Technical Manual.
3. No utilities will be affected by this project.
4. The subsurface utility information in this plan is utility quality level ___. This utility quality level was determined according to the guidelines of CI/ASCE 38- 02, entitled "Standard Guidelines for the Collection and Depiction of Existing Subsurface Utility Data."



6.3 SIGNAL DESIGN PROCESS

On accurate 1:40 Base Plan (1:500 Metric):

DESIGN STEP	DESIGN CONSIDERATION
6.3.1 Design Step 1 Create or Get an Accurate Drawing of the Intersection	• MnDOT uses MicroStation and all plans are required in this format. • Review preliminary design checklist • Retain coordinates within CADD file (if possible) • Review scope of project & project kick-off meeting info. • Request any additional survey or other information needed • Check sight distances • Check CADD file(s) for corrupt elements • Check truck turning • Review field walk information • Obtain field measurements as appropriate to confirm CADD file • Planned or highly likely geometric improvements should be shown on plans as dashed lines
6.3.2 Design Step 2 Confirm Signal Phasing	• Consider consistency in corridor operations when determining signal phasing • Work with signal operations to determine signal phasing



DESIGN STEP	DESIGN CONSIDERATION

6.3.3 Design Step 3
 	
Draw "Box" to Establish Crosswalks, Stop Lines and Pedestrian Ramps
	• Location
	• Type
	  ○ Parallel lines
	  ○ Zebra
	• Locate curb lines
	• Locate stop lines
	• Consider ops./phasing diagram (issues like split phasing)
	• Review pedestrian movements/planned improvements with local agencies
	• Review pedestrian facilities design considerations (see below).
	• Review pedestrian ramps and identify work needed

Pedestrian Facilities Design Considerations

Engineering judgment and experience will direct the responses to the considerations.

Pedestrian amenities include: pedestrian indications, pedestrian push buttons, pedestrian pavement markings (crosswalks), pedestrian ramps, sidewalk, and type R signs, APS.

In addition, refer to Accessible Pedestrian Signals (APS) on page **4-2**.

The designer should check with the MnDOT Traffic Engineering Project Manager to determine the district standard for pedestrian pavement markings and stop lines.

1. Preliminary Considerations

- What are the concerns of the local municipality and/or road authority? Are these concerns political or engineering related? Do these concerns have merit?
- Are there any documented pedestrian concerns for the area and/or particular intersection? Review if available.
- What is the current zoning for undeveloped property? Is development imminent? Is the zoning likely to change?
- Is the area residential, urban or rural in development, commercial business district?
- Are there pedestrian generators in the area?
- What pedestrian movements are provided at near signals?
- What are the inplace or planned bus routes/light rail/ bike paths/sidewalk?
- What warrants are applicable to the signal? (school/pedestrian volumes)
- Is the age of likely pedestrians an issue? (schools/retirement complexes)

2. Roadway Geometric Considerations

- What median is inplace or shall be constructed for system? Is the median width appropriate for pedestrian haven?
- Are there geometric limitations to the system that restrict pedestrian movements? (i.e. adjacent bridge without pedestrian provisions, adjacent retaining walls/ physical constraints, etc.).
- With what type of roadway geometrics will the system operate? (4 legs, T-intersection, etc.).

3. Preparatory Work for Specific Design Situation

- Review accident studies.
- Review available pedestrian counts. If not available, is it appropriate/feasible to obtain accurate pedestrian counts?
- Perform a field review. What are the inplace pedestrian crossings and amenities? Is it appropriate to propagate all the inplace crossings?
- Are there any known safety issues such as pedestrian paths or visibility?
- Are there inplace utilities that will impact the design?

4. General Operational Considerations

- Are pedestrians being prohibited inappropriately?
- Is a single crossing over the trunk highway mainline appropriate?
- Are standard operational considerations appropriate? (i.e. 3.5 feet per second rate, coordination, pedestrian recall).

5. Pedestrian Facilities for Traffic control signal system

- What can be accomplished? Is the signal work a revision/rebuild (existing pedestrian patterns?)/new signal?
- Are push buttons in the median feasible – geometric, maintenance and operational (winter and safe haven) concerns? If placed within the median, on which side or sides should the push buttons be placed?
- Are pedestrian ramps and sidewalk inplace within the median and in appropriate locations? If not in conformance or not inplace, should ramps and/or sidewalk be placed?
- Are pedestrian ramps and pavement markings inplace? Are in place ramps and markings in conformance with the 2010 ADA Standards with Amendment? Are plow friendly corners needed?
- Is sidewalk inplace? Does inplace sidewalk coincide with pedestrian ramps and movements? Is new or additional sidewalk necessary?
- For identified pedestrian crossings, are both indications (international) and push buttons appropriate or are combinations of the items appropriate?
- If pedestrian indications and/or push buttons are not provided at specific crossings, it may be appropriate to include spare wires for possible future use.

All corners of a signal plan set may requires a separate sheet with all APS details. This is to help clarify the APS requirements on each corner, and each corner may be different (see sample plan 20 scale drawing). Refer to Section **4.3** for the Draft Accessibility Guidelines. It is the goal to meet each of the requirements of the Accessibility Guidelines. Engineering judgment is necessary in cases where meeting the precise requirements is impossible.

It is important for the signal designer to work closely and directly with the road designer to address all pedestrian design elements. It is also important to refer to Division S of the Special Provisions regarding ADA

The MnDOT ADA Project Design Guide along with numerous other resources can be found at, http://www.dot.state.mn.us/ada/index.html. The following is the latest version of this document.

June 28, 2012

INTRODUCTION

The purpose of this document is to provide direction to designers and project staff involved in the development and design of ADA improvements and projects. This document will help eliminate confusion about the level of plan detail required for ADA facilities in project plans, as well as provide a comprehensive look at the potential impacts ADA elements have on design in other functional areas.

SCOPING

It is MnDOT's goal to meet the needs of all disabled users throughout its system. Every project that impacts pedestrian facilities should be considered an opportunity to achieve this goal and further the completion of the ADA Transition Plan. To ensure that a project is able to meet accessibility requirements a thorough scoping of accessibility needs is required. If a Pedestrian Scoping Process has not been performed, project staff must walk the project and complete the evaluation.

During the field walk project staff should determine what upgrades need to occur to meet all users' needs without regard to the project scope. Once all upgrades have been identified, the project staff will need to determine which features to include. Per MnDOT policy, all projects must provide curb ramps if they are needed and improve existing curb ramps that do not meet current minimum requirements. If there other accessibility needs that can be addressed by a slightly expanded project scope, MnDOT should take the opportunity to do so, considering that any unmet needs or substandard installations must be addressed by a future project. Accessibility needs beyond curb ramps include but are not limited to APS upgrades, sidewalk improvements, and barrier removals.

While ADA doesn't require the presence of facilities, at times the lack of facilities can present a true barrier for people with disabilities. Projects should note the presence of pedestrian activity (goat paths) as well as identify gaps in sidewalk connectivity and discuss the overall plans for these areas with the local governments.

If the District determines that either the project scope or timeline is insufficient to design and construct compliant curb ramps that meet the ADA needs, the District should confer with the ADA Office to determine if a Phased ADA Improvement Project will achieve a more accessible end product. This future project will need to be programmed independently or incorporated into a district wide stand-a-lone ADA project and provide the following information in the current Project Submittal Memo:

1.) New SP Number, Project Schedule, and Letting Date
2.) Cost Estimate with Clearly Documented Project Scope for next Project Manager
3.) PM Identified
4.) Funding Source Identified
5.) District Keeps list of Phased ADA Improvement Projects

It is important to remember Tech Memo No. 10-02-TR-01 *Public Rights-of-Way Accessibility Guidance* establishes the minimum threshold for when and what type of accessibility improvements must be made as part of projects that are constructed within MnDOT's rights-of-way. Any improvements that are minimally required, but will not be made at the time of the initiating project, will require a follow up project that will accommodate MnDOT's project development process and be delivered as soon as is feasible.

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PRE-DESIGN: DETERMINING THE LEVEL OF PLAN DETAIL & SURVEY NEEDS

Curb Ramp Retrofits

Depending on the project site characteristics and the mapping already available before the project begins, surveys may not need to collect a large amount of field data for a project, or they may create mapping from field surveys for the entire project. If mapping is available, design/surveys should make sure it is up to date and free from errors or omissions. It is important to remember that the accuracy and precision of the data collected by surveys isn't necessarily the level of output that is needed in the plan. In many cases the level of information that surveys provides will be greater than the level of information that is provided in the plan, especially with regard to elevations. Use the table below as a guide when determining the level of data needed in a curb ramp upgrade plan.

- 3 Levels of plan detail:
    1. Standard Plans
    2. Custom Design with X,Y location
    3. Custom Design in vertically constrained areas
- Different levels of plan detail can be used at different intersections/quadrants in the same plan
- Don't be over prescriptive or claim more accuracy than your data provides

Plan Level	Design Data	Plan Locations (X,Y)	Plan Elevations (Z)
1	DTM/Eye Level/Smart Level	No	No
2	Field Surveys	Yes	No
3	Field Surveys	Yes	Yes

Note: For Plan Level 1, the field data is only needed to provide estimated quantities within 20% accuracy. DTM assumes that a DTM is already available for the area, it does not mean surveys should create a new DTM. If a DTM is not available the designer can estimate the quantities by making a field visit and using a standard level, eye level, or smart level.

1.) Standard Plans – Standard plans can be used on ADA retrofit projects and mill & overlay projects. Signalized intersections and regrade projects should not use standard plans.

- The designer should determine if one of the standard plan designs can be easily applied to the quadrant in question.
- The grade breaks and ramp locations must line up with the inplace edge of the sidewalk or ROW limits
- If this is the case, the designer should estimate and tabulate the appropriate pay items (see ADA pay item guidance) by quadrant and include the proposed ramp type in the tabulation. The alternative to listing the curb ramp type in the tabulation is to note the different curb ramp types at their locations on the construction plan.
- Appropriate pay items include all pay items necessary to adjust all surface utilities affected in the construction area.
- Link to Level 1 Sample Plan: http://www.dot.state.mn.us/ada/pdf/level1.pdf

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2.) Custom Designs with X,Y location – When a standard design cannot be easily applied to a quadrant or the intersection is signalized, then a custom design must be provided. This design is usually a 20 scale detail of the intersection and shows where the ramps are located, including ramp ranges, landings, grade breaks, and X,Y coordinates of the curb cuts. It would also show the location of the signal system components as well as any other surface features/utilities. If a topographic map is already available in Microstation, then no surveying is needed unless the mapping is outdated. The designer should make field visits to determine the accuracy of the existing topographic mapping as well as to determine/check the proposed ramp designs.

3.) Custom Design in vertically constrained areas/Curb Line Changes on Mill & Overlay – This type of design should be used in areas where there are vertical constraints that must be met such as doorways, steps, private sidewalks/driveways (when we don't have ROW access to change the elevations of the private sidewalks/driveways). In this case the designer should create a custom curb ramp design that shows the grades and dimensions of the proposed ramps and landings and show how they will tie into the constrained area. By providing the exact proposed ramp grades and dimensions of the curb ramps along with a note describing what existing surface should be tied into, the plan is clear and contractor friendly. Surveys will be needed at quadrants that have these vertical constraints to help the designer establish these ramp grades and dimensions but exact elevations should not be listed in the plans.

Link to Level 2/3 Sample Plan: http://www.dot.state.mn.us/ada/pdf/levels2and3adaintersection.pdf

When the proposed curb ramp work requires changing the horizontal and vertical alignments of curb lines as part of a pavement preservation project, the designer should provide the same curb alignments and profiles that would typically be provided in roadway construction plans. This C&G alignment and profile information is needed to ensure the new curb matches the in place street surface and drainage is maintained. By only showing proposed curb line changes in the plans the field staff/contractor will more readily recognize the proposed changes in C&G placement and focus their efforts in these areas. In lieu of C&G information in the plan, the contractor is required to maintain existing flows patterns so simple drainage arrows should be provided on custom designs. X,Y,Z coordinates beyond the new curb line aren't needed to build the curb ramp and shouldn't be provided in the plans.

New Construction / Major Reconstruct

As projects get larger than a typical mill & overlay project, the curb ramp plans will become more integrated into the larger plan set. Custom curb ramp designs will generally be shown on the intersection detail sheets. These intersection sheets already contain curb line alignments and elevations so X,Y,Z coordinates (or gutter profiles) should be placed at each edge of each proposed curb ramp. If gutter profiles are used they should wrap around each radius and continue to the side street tie down point. Both PROWAG and MnDOT's road design manual require all cross walks to be constructed at a 2% maximum cross slope so this criteria should be achieved on intersection regrades and shown on the curb flow lines at all curb cuts to ensure the cross slope requirements are met for both the roadway and the pedestrian ramps.

The curb ramp designs should follow the same guidelines as level 2 and Level 3 designs described above showing landings, grade breaks, surface utilities, signal components if applicable and elevations in ranges or specific slopes based on the surrounding vertical tie in points (Doorways, stairways, etc.). Surveyors will have shot every adjacent tie-in point, such as doorways, so designers will need to verify curb ramps designs meet requirements but should not include excessive elevations in the plan. Generally an X,Y,Z point at the ramp landings and/or at the top of

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secondary ramps will be sufficient control for contractors to construct the designs properly. In areas with no critical vertical tie in points curb ramp should be designed to the point where the typical sidewalk section governs.

Designers should be aware this document is based on curb ramp construction. On major reconstruction/regrade projects many other pedestrian considerations occur with new sidewalk construction, such as matching into existing doorways and driveways while providing a Pedestrian Access Route throughout each block. Considerations need to be given to adjusting curb alignments, profiles, and curb heights to achieve a compliant, user friendly pedestrian design. In slow speed areas roadways should be designed from the outside in using adjacent off ROW vertical tie in points as the starting point for the design. Vertical roadway control should be based on gutter profiles and variable roadway cross slopes rather than centerline profiles and constant roadway cross slopes as has been the recent typical highway design practice - that has commonly resulted in excessive sidewalk cross slopes.

Once gutter profiles and curb heights have been set based on existing adjacent off ROW vertical tie in points, sidewalk cross slope break lines in wider sections of sidewalk can be created to provide a sloped boulevard area. If a cross slope break line is used other project aspects such as sidewalk width in front of doorways, sidewalk jointing patterns, along with locations of lighting bases, street furniture, etc. must be considered. To ensure the sloped boulevards are amenable to both parallel parking and pedestrians walking outside of the PAR, it is recommended to keep walkable boulevard slopes ranging from a preferred 8% to a maximum 12% cross slope. When utilizing a cross slope break line in the sidewalk, cross sections should be provided at doorway tie in points and a sidewalk profile should be generated to tie in these match points while ensuring sidewalk running slopes don't exceed 5%.

Driveways need to be surveyed and specific designs must be developed in vertically constrained areas which depict driveway running slopes as well as construction limits needed to acquire temporary access beyond the permanent ROW limits. It is strongly recommended to talk with the ADA office a minimum 2 years prior to letting to discuss project specifics (survey and ROW needs, typical sidewalk section, curb profiles, etc.).

DESIGN CONSIDERATIONS

The level of detail that should be provided in the plan is dependent upon each site. In some cases the Contractor may need precise elevations to bid/construct the facility correctly and in some cases they may only need a standard plan and estimated quantities. The designer's goal should be to provide enough detail to construct the most user and maintenance friendly compliant facility that fits the site, but not so much detail that excessive time and effort is wasted designing a facility that can be easily constructed with a standard plan/detail. Also, including too much detail in the plan may overly constrain the Contractor. In many cases the adjacent terrain dictates how a ramp blends in better than a detailed design. Another negative is when the plan is too prescriptive and some details are wrong, then MnDOT owns the mistake. Various levels of detail will exist within a plan and will be dependent on the specific site conditions. The plan should be easy to read and in a field friendly format so that it is easy to use in construction. The designer should also consider what the area will look like once the removals have been completed and then ask themselves if the level of information in the plan is sufficient to construct the facility.

Non-Signalized Intersections

- Use District curb ramp inventory and perform field walk to determine which curb ramps are non-compliant and need to be reconstructed with the project. If any failing sidewalks or other barriers are

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identified, the District should address these as part of the project. The ADA Office is available for field walks to assist in addressing unique situations.

- Determine whether surveying is needed or if a site visit is adequate to choose appropriate ramp types and determine necessary pay items. In urban areas with multiple surface utilities, buildings, and doorways, surveys will probably be necessary.

- Talk to local agencies/District Traffic staff/bike ped/ADA unit to determine whether pedestrian crossings should be added, removed, or kept in place and to determine if any future pedestrian facilities are planned or if the local government has a pedestrian master plan.

- Ask local agencies if there is a color of truncated dome they would prefer to be installed on the curb ramps and coordinate the replacement of any special surfaces (pavers, colored concrete, etc.). If the local agency wants these features put back, the designer should locate all pavers and heavily jointed walk outside of the Pedestrian Access Route. In lieu of a strong local preference, MnDOT should use non-colored truncated domes for system uniformity, better availability, reduced costs, and better durability because the paint doesn't wear off.

- As a rule, if a sidewalk approaches a trunk highway from a cross street, a curb ramp should be provided that provides access across the trunk highway unless there is a documented safety problem or adequate stopping sight distance cannot be achieved. See Minnesota Statute 169.011 Subd. 20 - Definition of "Crosswalk" https://www.revisor.leg.state.mn.us/statutes/?id=169.011

- Select appropriate curb ramp types that are constructible at the chosen quadrant. If standard ramp types will not work at a particular quadrant, then a custom ramp must be designed. Use sample plans as a guide when creating a custom design.

- Sample Plans Level 1: http://www.dot.state.mn.us/ada/pdf/level1.pdf

- Sample Plans Level 2: http://www.dot.state.mn.us/ada/pdf/levels2and3adaintersection.pdf

- The designer should provide the length and slope of the curb ramp [run] wherever that length is critical to the curb ramp's design. Critical areas may include proposed non-compliant ramps and areas where doorways are being matched.

- When designing parallel ramps and depressed corners with the sidewalk adjacent to the back of curb design ramp slopes at a 5-8 percent grade to minimize the length of curb height tapers from zero to full height curb.

- Typically designers should try to keep the arc length of depressed corner and fan designs to 20 feet or less whenever possible to avoid vehicle overturning.

- When creating Type 2 designs that use radial domes only provide one working point on the TH side of the curb ramp. The reason for this is because radial domes don't come in even arc lengths so it is best to require the contractor to determine the exact length of the curb cut.

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- If existing sidewalk width is greater than 7 feet, depressed corners and parallel ramps should not be used. More user/maintenance friendly ramps can often be designed/constructed.

- Limit the amount of V curb in the plans to areas where V curb will certainly be needed or ROW has talked with the adjacent property owner and V curb is the preferred option. V curb is a great tool when needed but grading/sloping is generally the preferred option. Flush/flat areas beyond the sidewalk are more maintenance friendly for snow clearing operations. These same flush/flat areas also allow mobility impaired users an escape route from over turning/errant vehicles on the sidewalk. Contracts provide for a fixed price for extra V curb for construction personnel to use as needed so there is no need to guess where V curb should be utilized in the design process.

- Send plans to the ADA office for review once ramp types have been selected/designed and street crossings have been chosen.

- Truncated domes width is 4' minimum. When designing curb ramps call for the truncated dome width to be 0.5' less than the width of the sidewalk the ramp is serving. For example, a 5' sidewalk should have 4.5' of truncated domes.

- If the project is a mill and overlay extend mill & overlay limits on side streets as necessary to replace the pavement in front of all curb ramps and the crosswalk pavement between the curb ramps.

- As a final check of all the intersections turn on all the files in Microstation: Construction plans, drainage plans, signal plan, utility plan, lighting plan, etc. and check for potential conflicts. Also, it is a good idea to take the proposed designs into the field and look at them to determine what the potential impacts will be during and after construction.

- Document all the decisions made regarding the addition or removal of pedestrian crossings, as well as any areas that do not meet ADA requirements and the actions taken by this project and/or future projects to help improve situations that do not meet ADA requirements. Take pictures of all inplace curb ramps and adjacent buildings and keep in project file for a record of the preconstruction condition.

Additional Considerations for Signalized Intersections

- Complete topographic surveys should be obtained at all signalized intersections.

- If crosswalks are moving it is important to know what the loop detector impacts will be, so it is helpful if the surveyor can work with Traffic to determine the location of the loops closest to the existing crosswalk. Considerations should be made for sight lines and locations where vehicles are stopping/anticipated stopping location when proposing crosswalk locations. Confer with the District Traffic office when proposing changes to crosswalk locations.

- The road designer and the signal designer should work together to produce a 20 scale intersection detail showing:

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- All signal system components (inplace and proposed) including signal poles, pedestal poles, cabinets, handholes, push button stations, and all surface utilities.
- Proposed curb ramp construction including truncated domes, ramps, landings, grade breaks, curb heights if applicable
- The detail should also provide X, Y coordinates for the curb ramp locations, signal poles, pedestals, and push button stations so that these locations can be staked by the surveyor in the field.

- When producing the 20 scale intersection detail, scale down the existing topo symbols so that they fit the sheet and aren't unusually large.

- If the municipality regularly removes snow from the pedestrian facilities at the intersection, send the proposed design to municipal staff so they can comment on impacts to maintenance. The designer should also send the design to MnDOT Maintenance for their comments. The designer should strive to meet their needs without violating the ADA criteria.

- There are three proven designs for quadrants with two APS locations:

  1. 2 – 6' wide 4' long perpendicular ramps
  2. Depressed corners
  3. Fans when crosswalks can't be separated and there are elevation concerns

  Directional ramps create inherent difficulties and should rarely be used when there are 2 push buttons at a quadrant.

- Some best practices when placing APS push buttons are:

  - Place buttons outside of truck turning radii;
  - Place buttons so that they don't obstruct the sidewalk/trail;
  - Maintain a 6' MAR (Maintenance Access Route) between obstructions;
  - Center the button on the landing;
  - Make use of existing signal poles located in the vicinity if intersection isn't skewed and their locations meet the APS requirements.

  Designers should optimize the push button locations to meet all the above criteria working in conjunction with MUTCD push button placement criteria.

- All signal components that are being installed on the job including poles and pedestals as well as push button stations must have XY coordinates provided so that the surveyor can stake their proposed locations in the field.

- When upgrading existing signals to APS and proposing to place a push button on an existing pole, the designer must verify that the push button will meet the height and direction requirements once the new curb ramp is constructed.

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- As a final check of all the intersections turn on all the files in Microstation: Construction plans, drainage plans, signal plan, utility plan, lighting plan, etc. and check for potential conflicts. Also, it is a good idea to take the proposed designs into the field and look at them to determine what the potential impacts will be during and after construction.

- Document all the decisions made regarding the addition or removal of pedestrian crossings, as well as any areas that do not meet ADA requirements and the actions taken by this project and/or future projects to help improve situations that do not meet ADA requirements. Take pictures of all inplace curb ramps and adjacent buildings and keep in project file for a record of the preconstruction condition.

SIGNALS

- If project is a standalone signal project (either new or replacement), utilize the design guidance listed above for signalized intersections.

- Visit the intersection to observe how traffic and pedestrians move/interact through the intersection and to see where vehicles commonly stop at the intersection. This is critical to placing crosswalks and APS push buttons in the proper locations. Also watch for pedestrians or evidence of pedestrian activity and note areas where pedestrian activity occurs.

- ~~If there is pedestrian activity at an intersection, install pedestrian crossings. Crossings should connect all existing and proposed pedestrian facilities (sidewalks and trails), all areas with pedestrian generators (i.e., gas stations, multiple residences, other destinations), and existing evidence of pedestrian activity (goat paths, pedestrian observations, push button counts, etc.). Crossings may also be required to provide a pedestrian phase when the vehicle crossing time (usually a pedestrian attempting to cross the main line) is insufficient to meet pedestrian crossing timing needs. If all else is equal and it is deemed only a single main line crossing is appropriate, it is generally preferred to choose the crossing with the least conflicting vehicle movements. The following groups should provide input on crossing location needs: District Traffic Office (Signal designer & TSAM in Metro), Project Manager/Designer, CO ADA, Bike and Ped, Local Agencies.~~

- Connect all existing and proposed pedestrian facilities (i.e. sidewalks and trails); quadrants with pedestrian activity (i.e. goat paths, pedestrian observations, push button counts, shoulder routes, or other identifiers); and existing destinations/generators. Pursue cooperation with LGU/property owner(s) to connect perceived crossings to nowhere. Crossings may also be required to provide a pedestrian phase when the vehicle crossing time is insufficient for a pedestrian to cross a leg. If only a single main line crossing is appropriate, it is generally preferred to choose the crossing with the least conflicting vehicle movements unless ADA-compliance and/or specific destinations/generators should be considered. The following groups should provide input on crossing location needs: District Traffic Office (Signal designer & TSAM in Metro), Project Manager/Designer, CO ADA, Bike and Ped, and Local Agencies.

- If a signal has pedestrian push buttons these buttons need to be readily accessible. On rural roadway sections this can generally be accomplished with a flat landing/pad with truncated domes delineating the edge of the roadway. On urban roadway designs with curb ramps this often means the button placement needs to be coordinated with the ramp design/construction so the buttons are adjacent to a landing that is connected to the PAR. To achieve the best ramp designs and allow for phased accessibility

improvements, push button stations will likely need to be relocated with conduits placed beneath the walk so the push buttons will work in conjunction with the ped ramps. (See Interim APS Policy below)

- Consult the ADA office no later than 30% plans to verify crossing needs and APS potential, and prepare a list of steps taken/information gathered prior to consulting with the ADA office.

- New Signal and Signal Replacement Installations should be sent into the ADA Office a minimum of two years before letting to ensure a successful installation that will meet pedestrian needs for the 30+ years of the signal's life. Potential project needs such as ROW, Agreements, curb locations, and trail alignments among other factors must be considered.

- Note*** Refer to Scoping Section and Meeting Pedestrian Needs. If a Mill and Overlay project cannot meet the pedestrian needs due to problematic signal locations, ROW, or similar obstacles consider moving up signal replacement in the District Program.

Interim APS Policy

- APS installations are required on all pedestrian crossings on new signal system installations, signal system replacements, and major signal system renovations.

- Upgrading to APS is much more cost effective with a Mill & Overlay project versus a stand alone APS upgrade project. This is due to the fact that the curb ramps and any cross walk location modifications are already included in the project budget. In order to strategically complete MnDOT's ADA Transition Plan, all signals that have pedestrian facilities will be upgraded on mill and overlay projects to either full APS or APS "ready" if feasible.

- "APS Ready" is defined as all underground work necessary to upgrade the traffic signal to a fully compliant APS install without redoing the curb ramps or cross walk locations. In urban areas with existing pedestrian facilities this generally means relocating the solid state push buttons to new locations coordinated with the pedestrian ramp upgrades. In rural areas with flat landings this can mean simply ensuring conduits can easily be run to future compliant APS push button stations without regrading/reconstructing the pedestrian ramps.

- If a signal is not being upgraded to APS or APS "ready", the District must document in the Project Memo why APS or APS "ready" improvements are not being included. Some feasibility considerations are the availability of existing spare wires for APS, ability of conduits beneath roadway to accommodate additional wires, compatibility of existing hardware, etc. or the signal is already scheduled for upgrade in the STIP. District Traffic Offices need to make this feasibility assessment for all signals with pedestrian facilities within the project limits. If these upgrades are deemed infeasible on the current signal system and there are significant pedestrian needs, evaluate replacement of the signal in relation to the District's signal replacement plan.

SURVEYS

- During the initial field walk, the designer should determine what the survey needs are for the project.

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- All Level 2 & Level 3 Designs should be surveyed. This entails all signalized intersections, as well as any intersections that will require custom designs, such as intersections with multiple buildings, doorways, surface utilities, and other obstructions.

- Any areas with drainage problems or possible curb line movements (horizontal or vertical) will also need to be surveyed. Potential bump out areas and other curb line realignments into the roadway surface should be identified in the field walk and on the survey request so surveys personnel perform a more detailed topo in these critical roadway quadrants in front of the changed C&G. A TIN file generated from field surveys is very beneficial for these areas to ensure drainage is maintained and the proposed curb and gutter will match the inplace roadway surface.

- Surveys should locate: all surface utilities that may be impacted by pedestrian facility construction, including but not limited to handholes, manholes, hydrants, gate valves, drainage structures, signal system components (poles, push button stations, pedestals, cabinets, loop detectors), light poles, telephone/cable boxes, fiber optic vaults, and irrigation/sprinkler heads or services if visible near the sidewalk. Survey shots should be taken on the opposite sides of signal foundations so that the true size/location of the feature is shown in the plan. Also locate: buildings and doorways, other permanent features in or near the sidewalk area such as landscaping, retaining walls, planters, benches, sign posts, etc., existing crosswalk striping, and medians.

- On all sidewalk/curb ramp projects surveys should locate any existing lot corners/property irons that could be disturbed as a result of construction. This has nothing to do with ADA, but it is a courtesy MnDOT should provide to the property owners and future owners/surveyors to restore any existing monumentation that will potentially be obliterated as a result of the project.

DRAINAGE

- Field walk/drive the project after a rain event to determine if any water is ponding in the curb ramp areas. Any ponding issues in front of curb ramps should be remedied as part of the project. Request surveys to profile any areas that are ponding and provide new curb line profiles in the plan. Also call for casting elevation adjustments as necessary.

- If catch basin grates are located in the pedestrian access route, the grate needs to be replaced with an ADA compliant grate, or the structure needs to be relocated. Ideally the structures would be located 5-10 feet outside the pedestrian access route, but if this is not feasible a special grate that meets ADA requirements may be used. PROWAG section R302.7 states the requirements for a compliant grate. The horizontal openings shall not permit the passage of a sphere more than 0.5” in diameter and the elongated openings shall be placed so that the long dimension is perpendicular to the dominant direction of travel.

- In new construction, if curb flowlines are designed so that water is intended to flow around the curb radius and continue down the street, it is recommended that a structure be placed on the upstream side of the curb ramps to keep water and debris from flowing across curb ramps.

- Determine drainage impacts created by any proposed curb line movements. Curb bump-outs and radius reductions are often part of ADA upgrades, and drainage will have to be addressed as part of these

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modifications. When curb lines are changing, the designer must provide both a horizontal alignment and a vertical profile. The designer shall also verify the proposed curb lines will match the inplace road elevations.

- Curb Box removals may be needed to properly construct curb ramps. Curb box removal is OK for structures on grade. At sag points analyze whether curb box is needed early in design process and if it is needed expand the scope of the project to relocate the drainage structure.

- Add flow arrows to intersection details on Level 2 & Level 3 designs so construction knows which way water is flowing.

- Installing curb and gutter through the new curb ramp area is preferred to provide better drainage and a longer lasting product. In overlaid gutter areas, this entails pouring new concrete curb and gutter to match into existing bituminous flowlines. The only place curb and gutter should not be installed is rural roadway sections with no adjacent curb and gutter. In rural areas where we are not installing curb and gutter call for the truncated domes to be placed 1 foot back from the edge of the roadway to provide an adequate contrasting concrete border in front of the truncated domes as shown in a detail on the curb ramp standard plans.

MATERIALS

- If curb ramps are not part of a mill and overlay project, some sort of pavement treatment must be called for in front of the curb and gutter. Typically the gutter inslope will be reduced at the curb ramps which will result in the gutter face being lowered ¼" to ¾". Thus a new pavement treatment must be provided in front of the curb and gutter to tie the new gutter face into the existing pavement.

    - If the pavement is concrete, the designer should work with the District materials office, concrete office, and CO ADA to determine an appropriate design.
    - If the pavement is bituminous, three different treatment options exist:
        1. If the pavement is in good condition, the designer should call for a 2' wide 2" deep mill and patch.
        2. If the pavement is in poor condition, the designer should call for full depth removal of the bituminous pavement 2' beyond the curb line using a radial sawcut. The patch can consist of either:
            a. Full depth bituminous or
            b. Concrete poured up to a height 2" below finish grade, with a bituminous patch placed over the concrete. The designer should work with the materials engineer to determine a mix design that is locally available and meets the ESAL requirements of the roadway. Specify the design mix in the plan SEQ or soils and construction notes.

- The Project Engineer should work with Materials and Design to determine the appropriate pavement treatments associated with curb ramp work on mill and overlay projects. The ADA Office recommends making any bituminous removal and patching necessary to properly construct curb and gutter and provide TPAR on mill and overlay projects incidental unless there are multiple curb line changes which require removal of large areas of pavement.

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UTILITIES

For stand-alone ADA improvement projects:

- Perform Gopher State One Call as specified in the MnDOT utility identification process to determine what utilities are within the project limits and the owners of any impacted utilities.

- The designer should identify all the surface utility impacts during the field walk and include adjustments in the plan.

    - For non-MnDOT owned utilities, the designer must contact all of the utility owners to verify location and ownership and to determine what, if any, impacts the project will have on their facilities. The designer should verify whether the relocation of impacted utilities qualifies for reimbursement or if the relocation cost is the responsibility of the utility owner. Contact the Utility Agreements Unit for questions regarding utility reimbursement. If the utility does qualify for reimbursement, a utility relocation agreement may be required.
    - For impacted utilities, the designer should confer with the utility owner to determine if an adjustment can be included in the plan to be performed by MnDOT's contractor or if the utility owner needs to adjust the utility facility themselves.

- For impacted municipal utilities which would not qualify for reimbursement:

    - If a cooperative agreement with the municipality is required, the cost of the utility adjustments will be incorporated into that agreement.
    - If no cooperative agreement will be executed, the utility work can be incorporated into the project provided the cost of all work on the project for the municipality is less than $5,000. If the cost is more than $5,000 a utility relocation agreement will be required.

- For impacted private utilities, any work incorporated into the project requires a utility relocation agreement.

- Utilities that cannot be adjusted/relocated by the Contractor should be addressed using the steps for utility adjustment/relocation in MnDOT's Utility Process.

    - If the project will not affect ANY utilities, the designer includes the following in the plan:
        - The utility quality level note
        - A note stating, "The following utility owners have facilities within the limits of the project but will not be affected by construction"
        - A list of the utility owners with facilities in the project limits.
    - If there are any utility facilities within the project limits that are not affected and do not show up on the plan sheets, the designer also includes a note stating, "The following utility owners have facilities within the limits of the project but will not be affected by construction" and a list of those utility owners.
    - If the project will affect utilities, the designer includes the following in the plan:
        - The utility quality level note

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        - All impacted utilities shall be shown in the plan and/or be accounted for in the tabs or appropriate notes on the plan sheets. If there are any excavation areas in the project greater than 1 foot in depth or any signal work, the utilities in the excavation area and at the signalized intersections shall be shown in the plan.
        - A note indicating if any transmission lines are 69kV or more
    - If the utility identification was done more than 90 days prior to letting, another utility verification will be required per Minnesota Statutes.

- For projects in which the ADA improvements are included in a larger project, the standard utility coordination and plan requirements will be followed, but curb ramp construction areas would not require showing underground utilities in those areas or tabulation of any unaffected utilities because curb ramp construction should have a minimal impact on underground utilities and the contractor will still be required to use Gopher One Call.

RIGHT OF WAY

- If the existing sidewalk footprint is insufficient to meet the proposed design, verify ROW limits to see if MnDOT owns any ROW beyond the edge of sidewalk.

- If ROW is not known and cannot be determined, follow the streamlined ROW process to acquire 5' of temporary easement based off the edge of the existing sidewalk. Link to streamlined ROW process: http://www.dot.state.mn.us/ada/pdf/streamlinedacquisitionprocess.pdf

- There will be cases where a compliant curb ramp cannot be constructed within the available ROW. If this is the case, these curb ramps should be placed in a project where the timeline allows for the purchase of permanent ROW.

- In areas where V curb is proposed due to the lowering of the sidewalk elevation, ROW should consult with the adjacent property owner to inform them of the V curb option and discuss sloping their adjacent property as an alternate. Any agreements made with the property owner affecting the proposed construction should be relayed to the designer in order to incorporate the work in to the plans.

- Obtain Commissioner's Orders as needed to complete work that falls within local ROW

- For Level 1 plans that use details rather than site specific designs, a note should be include in the plan stating the temporary easement limits so that the contractor is aware of the working limits.

TRAFFIC CONTROL/TEMPORARY PEDESTRIAN ACCESS ROUTES

- The traffic engineer and project staff should look at the pedestrian needs on the project and put a concept of how to accommodate the need in the plans.

- Some options to consider are: A) Making use of a roadway lane, shoulder, or parking area if available, B) Crossing peds to the other side of the street and then crossing them back, C) Providing a reasonable detour. If providing a detour a route must be identified in the plans and coordinated with the local road authority.

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- When TPAR is not practical pinch the staging timelines to a defined period of time so that pedestrian facilities are interrupted for as little time as possible or constrain work to defined areas. (Get work done quickly in these constrained areas or break project up into phases based on existing pedestrian networks).

- The Project Engineer should work with Materials and Design to determine the appropriate pavement treatments associated with curb ramp work on mill and overlay projects. The ADA Office recommends making any bituminous removal and patching necessary to properly construct curb and gutter and provide TPAR on mill and overlay projects incidental unless there are multiple curb line changes which require removal of large areas of pavement.

- See Office of Traffic, Safety, and Technology website for more information: http://www.dot.state.mn.us/trafficeng/workzone/tpar.html

SIGNING/STRIPING

- Always try to place signs outside of the sidewalk and curb ramp areas. If signs must be placed in the sidewalk area, place them as close to the edge of the sidewalk as possible and try to line them up with other obstructions such as light poles, fire hydrants, power poles, etc.

- Crosswalks should be striped so that they line up with the new curb ramps. The designer should try to design crosswalks which run in a straight line across the entire roadway and are not kinked. If a crosswalk has a kink in it, the kink must point away from the intersection and occur at a median refuge to allow visually impaired users to realign their path of travel.

- If a problem is identified or anticipated with vehicles stopping on the crosswalks a stop bar should be added and possibly a “Stop Here On Red” sign.

- There has been an overuse of the “No Ped Crossing” sign. It should not be used in default of not providing a crossing. It should only be used where crossings are deemed unsafe.

PORK CHOP ISLANDS

- Pork chop channelization islands typically require complete reconstruction to achieve ADA compliance unless they are so large that 3 independent ramps can be constructed.

- To properly design pork chop islands, surveys should shoot the gutter flowlines around the island as well as any utilities/signal components and signs located in the island and the roadway surface surrounding the island.

- If the entire island is being rebuilt, it should be rebuilt using 4” curb to help lessen the amount of grade the curb ramp needs to make up. In some cases it may be necessary to have inverse ramp grades to achieve compliant curb ramps in an island.

- Use of output gutter may be needed to achieve compliant curb ramp designs.

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- The designer should also analyze the turning movements around the island and increase the size of the island if possible rather than having at grade cut-through ramps in the island. Redesigning islands may seem like a substantial amount of work, but it is one of the best places to spend time to provide a design that is a better pedestrian facility and is also maintenance friendly for snow clearing on the island.

- As an alternative to at grade cut-throughs, rise to the mid height of the curb with a 2.5' to 3' ramp and taper up to the curb height on the sides of the ramp.

- The minimum PAR width in islands is 5 feet.

MEDIANS

- The location of the crosswalk, width of the median, and the section of roadway (urban vs. rural), are the three factors that will determine the design of the pedestrian crossing at a median. If a median is impacting a pedestrian crossing, the plan should show how this impact is being mitigated.

- To properly design urban medians, surveys should shoot the gutter flowlines around the median as well as any utilities/signal components and signs located in the island.

- If the median is 6' wide from back of curb to back of curb, or wider at the crosswalk, it is considered a refuge for pedestrians and truncated domes should be installed. Also, if it is a signalized intersection, a push button should be installed in the median of the major crossings if recommended by District Traffic Office.

- If the crosswalk is located in front of or nearly in front of the median, the median nose should be pulled back to the point where the front of the snowplow nose is at the edge of the crosswalk.

- If the crosswalk runs through the median, the width of the median and section of roadway will determine the pedestrian ramp design.

- Rural Medians – If the median is 6' wide or wider, then the typical treatment is to construct a concrete pad 6' wide truncated domes at the crosswalks placed in a directional manner. In some cases this may require partially cutting into the existing pavement to construct the pad.

- Truck turning movements should be run in order to design the truncated domes in the median to keep trucks from turning over them.

- Urban Medians - If the median is less than 9' in width, then the design will likely be an at-grade cut-through between the flowlines with 1:4 tapers on each side of the PAR. The width of the PAR in medians must be 5' minimum, but 6' is more sensible to match the width of the crosswalk. If the median width is 10' or greater, then curb ramps can be installed with 4' of landing between them. Any remaining grade that cannot be made due to the limitations of curb ramp slope should be made up with 1:4 curb/side tapers. This recommendation assumes flowline elevations are the same on both sides of the median. Actual site elevations will determine the best design and whether or not a landing is achievable.

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CONSTRUCTION

- 1803 – (Prosecution of Work) Special Provision along with concrete walk and curb and gutter special provisions spell out what the critical elements are when constructing curb ramps. 1803 also states the responsibilities of the Contractor and the Engineer when constructing curb ramps and signals. This is a collaborative effort. The contractor constructs the project according to the plans and specs and MnDOT verifies the construction meets the plans and specs and is ready and available to help the contractor deal with varying site conditions.

- At a minimum, one inspector should have a smart level for conducting compliance checks and checking grades. A laser or eye level can also be a handy tool for determining elevation differences if available.

- Projects with ADA improvements should be staffed appropriately. It can be taxing to expect one person to handle all the layout issues and questions, while at the same time being responsible for materials testing, inspecting traffic control, quantities tracking, and conducting daily compliance checks. This becomes even more onerous when the project is spread out and the contractor is working multiple crews.

- When problems/questions arise consult with the project designer and the ADA office. Don't feel pressured to make an immediate decision.

- Compliance checks should be performed daily after every concrete pour to ensure the contractor is constructing the facilities properly. Provide constant feedback to the contractor about how they're doing, whether it's good or bad. We will be buying the product so we want to make sure it's right. Turn in the compliance checklists to the ADA office once the job is complete.

- Pay items have been combined so the inspectors can spend less time "bean counting" and more time ensuring that the contractor is producing a quality product.

- Mill and overlay projects should be staged with the curb ramps as an initial separate construction phase.

- Contract time is a very important component of these projects. Either too much or too little time can have detrimental effects on staffing and quality. If there's any questions or concerns contact OCIC and/or ADA unit.

- The Project Engineer should work with Materials and Design to determine the appropriate pavement treatments associated with curb ramp work on mill and overlay projects. The ADA Office recommends making any bituminous removal and patching necessary to properly construct curb and gutter and provide TPAR on mill and overlay projects incidental unless there are multiple curb line changes which require removal of large areas of pavement.

TRAILS/PEDESTRIAN FACILITIES

- The maximum allowable profile grade (longitudinal slope) for pedestrian trails that are not adjacent to a road is 5.0%. If adverse impacts to the surrounding landscape require the facility to exceed a 5.0% grade then the design should mitigate the situation by reducing the cross slope of these areas to 0.5% and provide 5' X 5' resting areas on the uphill side of the trail at 200 feet intervals. See the following

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document for additional guidance:
http://www.fhwa.dot.gov/environment/sidewalk2/pdf/15chapter14.pdf

- Design the cross slope of all pedestrian facilities at 1.5%.

- Avoid placing sidewalks and trails immediately adjacent to the back of curb. Maintaining a 4-6 feet boulevard between the back of curb and the sidewalk has multiple benefits. It improves trail user safety due to separation from vehicular traffic, it allows for better driveway designs, it allows for better curb ramp designs at intersections, and minimizes the changes in direction of the pedestrian access route (PAR), which allows users to travel in a straight line.

- The width of typical shared-use trails typically does not allow a standard curb ramp design, therefore a modified one-way directional ramp design must be used that places the truncated domes at the back of curb.

- Typically, truncated domes and curb cuts should be the full width of the shared use trail. However, this may not always be true at signalized intersections with multiple crossings and APS push buttons.

- At signalized intersections, plan sheets should follow the Plan Level 2 format and trails should be typically be aligned so that they come into the curb line behind the pedestrian push buttons if possible. In certain cases it may be necessary for the push buttons to encroach into the trail to meet push button location requirements. Push buttons may encroach 1 foot into an 8 feet wide trail and 2 feet into a 10 feet wide trail in order to meet ADA compliance.

- To design curb ramps for trails that are not at signalized intersections, the construction plan should show the locations of the truncated domes, grade breaks, and hatched landing locations.

PAY ITEM GUIDANCE

- Remove and Replace Bituminous Pavement pay item should not be used for BOC pavements. Use either the Mill and Patch Bituminous Pavement pay item or traditional pay items.

- All pay items should be tabulated independently for each quadrant. Note: if radial truncated domes are needed, the proposed radius and quantity must be provided for each quadrant. Include a note in the plan: “Sawcuts shall be provided at all curb and gutter and sidewalk removal limits and all sawcutting of curb and gutter and sidewalks is incidental.”

- It is possible that some projects will have items which are incidental for curb ramp work and paid for when being used on another part of the project. For example, aggregate base will be incidental for curb ramps but still paid when being used for a pipe replacement. Another example would be in some cases patching material in front of curb ramps may be incidental while patching material for roadway patching would be paid for with a pay item.

- In areas where curb lines are changing and large sections of the road will need to be removed, traditional pavement removal and patching items should be used.

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- Link to Pay Item Example Projects: http://www.dot.state.mn.us/ada/pdf/adaprojectpayitemexamples.pdf
- Link to Special Provisions for ADA Pay Items: (Note: Use SP2005 Book when preparing project proposals) http://www.dot.state.mn.us/ada/pdf/specialprovisionsadapayitems.pdf

Standalone Signal Projects/ADA Retrofits

1) Remove Curb and Gutter – Indicate sawcuts are incidental with a note in the SEQ.
   (2104.501 Remove Curb and Gutter – LIN FT)
2) Remove Concrete Walk – Indicate sawcuts are incidental with a note in the SEQ.
   (2104.503 Remove Concrete Walk – SQ FT)
3) Mill and Patch Bituminous Pavement – Use for bituminous pavements in good condition.
   (2232.603 Mill and Patch Bituminous Pavement – LIN FT)
4) Remove and Replace Bituminous Pavement – Use for bituminous pavements in poor condition.
   (2104.603 Remove and Replace Bituminous Pavement – LIN FT)
5) Concrete Curb and Gutter
   (2531.603 Concrete Curb & Gutter – LIN FT)
6) Concrete Walk
   (2521.618 Concrete Walk – SQ FT)
7) Truncated Domes
   (2531.618 Truncated Domes – SQ FT)
8) Concrete Curb Design V
   (2531.603 Concrete Curb Design V – LIN FT)
9) Turf Establishment and Grading
   (2575.602 Site Restoration – EACH)
   - The Designer should provide grading quantities for all borrow material expected to be over 8 CY (CV) at a quadrant.
   - If the borrow quantity measured in the field is greater than 8 CY (CV) at any particular quadrant and that quantity is not specifically provided for in the plan, the contractor will receive a fixed price for all borrow in that quadrant.
   - Use 2106 specifications and pay items when paying for grading on curb ramp projects.
   - Excavation/borrow quantities that are expected to be less than 8 CY (CV) at a quadrant are incidental unless specifically provided for in the plan.

Mill & Overlay with Curb Ramps

1) Remove Curb and Gutter – Indicate sawcuts are incidental with a note in the SEQ.
   (2104.501 Remove Curb and Gutter – LIN FT)
2) Remove Concrete Walk – Indicate sawcuts are incidental with a note in the SEQ.
   (2104.503 Remove Concrete Walk – SQ FT)
3) Concrete Curb and Gutter
   (2531.603 Concrete Curb & Gutter – LIN FT)
4) Concrete Walk
   (2521.618 Concrete Walk – SQ FT)
5) Truncated Domes
   (2531.618 Truncated Domes – SQ FT)

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6) Concrete Curb Design V
   (2531.603 Concrete Curb Design V – LIN FT)
7) Turf Establishment and Grading
   (2575.602 Site Restoration – EACH)

Large Grading/Regrading Projects and /or Projects with Large Quantities of Sidewalk

1) Use Specific Curb and Gutter types B624, etc…..ADA Standard Plan sheets will be included in all plans.
2) Truncated Domes
3) 4" Concrete Walk for the sidewalks and 6" Concrete Walk in curb ramp areas
4) Concrete Curb Design V (2531.603 Concrete Curb Design V – LIN FT)

6.3.4 Pedestrian Control Features

The information following this sheet is a handout taken from the Minnesota Manual on Uniform Traffic Control Devices (MN MUTCD) pages 4E-1 to 4E-8.

The most current version of the MN MUTCD can be found at:

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

Note: It is recommended that you review all original reference material.

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.

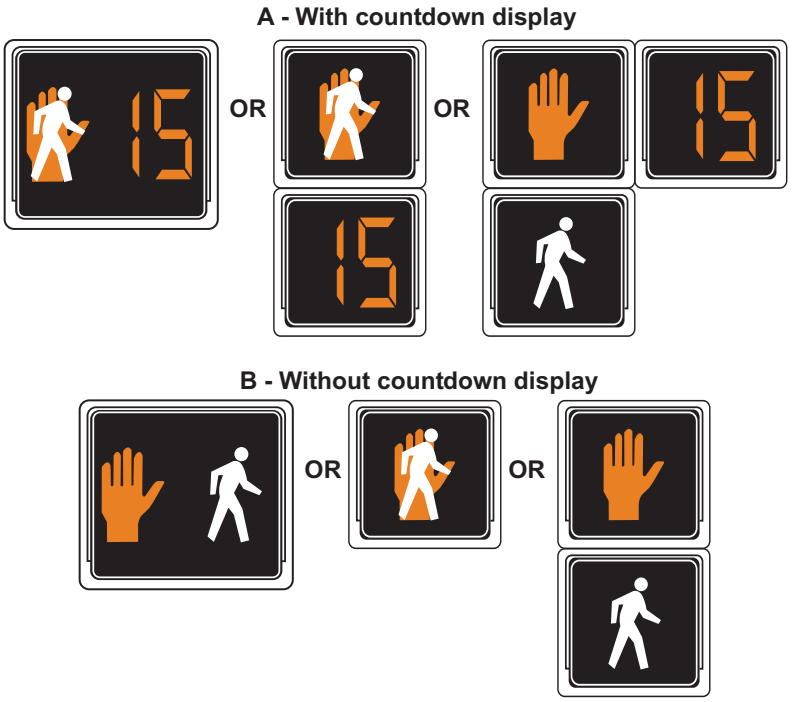

Figure 4E-1. Typical Pedestrian Signal Indications

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.

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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:

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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.

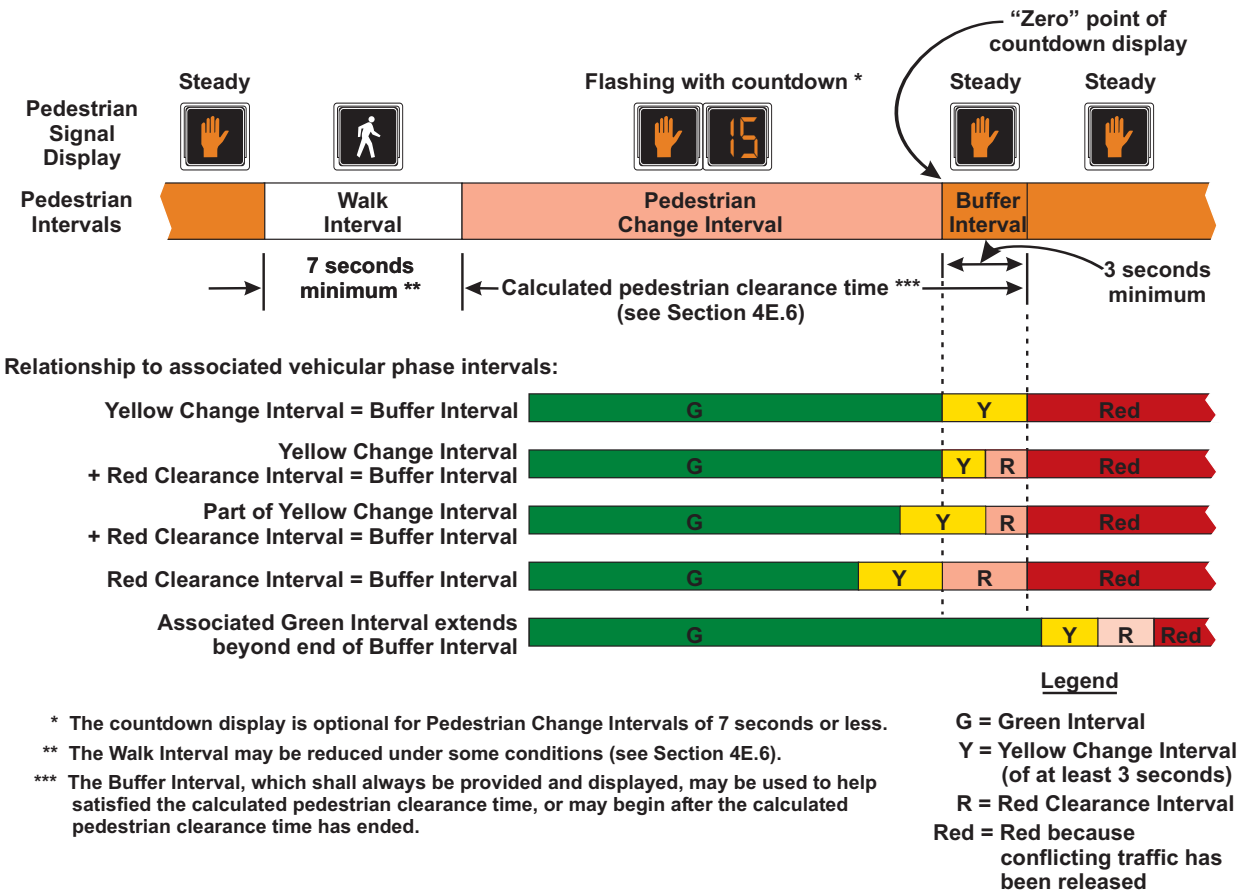
OPTION:

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.



* The countdown display is optional for Pedestrian Change Intervals of 7 seconds or less.

** The Walk Interval may be reduced under some conditions (see Section 4E.6).

*** The Buffer Interval, which shall always be provided and displayed, may be used to help satisfied the calculated pedestrian clearance time, or may begin after the calculated pedestrian clearance time has ended.

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

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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:

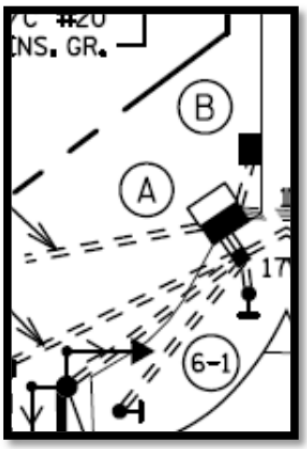
If speech pushbutton information messages are made available by actuating the accessible pedestrian signal detector, they shall only be actuated when the walk interval is not timing. They shall begin with the term "Wait," followed by intersection identification information modeled after: "Wait to cross 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.

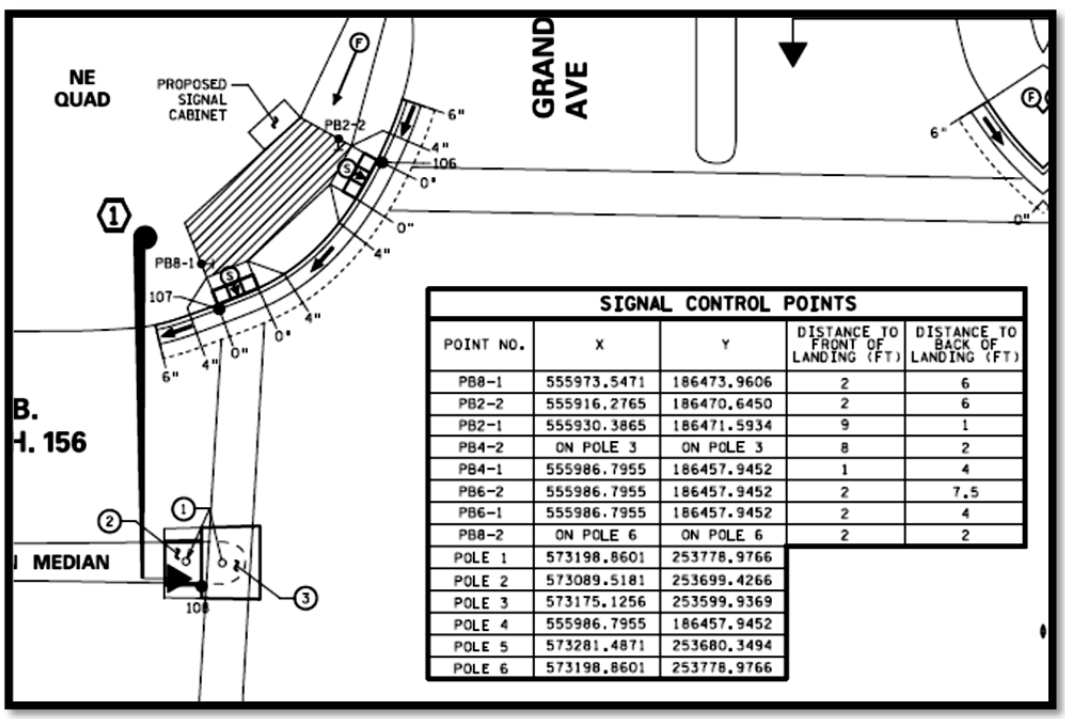
SUPPORT:

Additional information on the structure and wording of speech pushbutton information messages is included in ITE's "Electronic Toolbox for Making Intersections More Accessible

DESIGN STEP	DESIGN CONSIDERATION
6.3.5 Design Step 4 Locate Source of Power (SOP) and Cabinet (A) EQUIPMENT PAD (SEE DETAIL SHEET) SERVICE CABINET (SSB) CONTROLLER AND CABINET (STATE FURNISHED) 4" CONDUIT TO HH 17: 2-12/C #14 1-6/C #14 2-4/C #14 * 1-3/C #14 2-2/C #14 * 1-3/C #20 4" CONDUIT TO HH 1: 2-12/C #14 1-6/C #14 6-2/C #14 * 1-3/C #20 4" CONDUIT TO HH 17: 2-12/C #14 1-6/C #14 2-4/C #14 * 1-3/C #14 11-2/C #14 * 1-3/C #20 1-1/C #6 INS. GR. 4" CONDUIT TO HH 1: 2-12/C #14 1-6/C #14 4-4/C #14 * 1-3/C #14 7-2/C #14 * 1-3/C #20 1-1/C #6 INS. GR. 2-2" AND 1-3" CONDUIT STUBBED OUT (CAPPED BOTH ENDS 3/4" CONDUIT STUBBED OUT (FOR TELEPHONE LINE) ** 1-1/2" CONDUIT TO TMS VAULT: ** 1-FO PIGTAIL (6-SM) CONTROLLER CABINET TO SERVICE CABINET: 2" CONDUIT 2-1/C #6 1-1/C #6 INS. GR. CONTROLLER CABINET TO SERVICE CABINET (COMMS): 2" CONDUIT 1-6PR #19 SERVICE CABINET TO GROUND MOUNTED TRANSFORMER: 2" CONDUIT 3-1/C #2 SERVICE CABINET TO HH 17: 2" CONDUIT 2-3/C #14 (LUM) HH 17 TO HH 1: 2" CONDUIT 1-3/C #14 (LUM)  (B) SOP-GROUND MOUNTED TRANSFORMER (XCEL ENERGY) 2" CONDUIT INTO SERVICE CABINET: 3-1/C #2	• SOP – Confirm with power company/work with local representative o 3-1/C#2 from SOP to service cabinet o Meter, disconnect, load center requirements o Review if joint pad with lighting or Traffic Management system is appropriate o Use SOP checklist in meeting with power company o Complete SOP letter and any utility company permits – provide copy to constr. engineer and Traffic Engineering Project Manager o Clearly identify who furnishes, who installs conduit, cable, riser, wood pole, weather head or other specialized equipment within the plan o Clearly identify if luminaires metered or not • Cabinet (SSB and Controller Cabinet) o 3-1/C #6 insulated ground from cabinet to service cabinet o 1-6pr #19 from SSB cabinet to controller cabinet o Adequate R/W o Place cabinet higher then HH to keep water from running into cabinet o Does not interfere with pedestrians o Intersection readily visible from cabinet o Snow placement/do not block cabinet o Facilitates placement of interconnect o Convenient to SOP o Orientation – consider providing sidewalk at doorside o If using one cabinet for diamond ramp interchange operation, check with signal operator for cabinet placement o Work with road designer to facilitate grading a cabinet location o Clearly identify if luminaires metered or not o Will battery backup be used? if batteries are not to be included the 6/pr #19 should be shown as spare for future monitoring of back-up system.

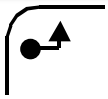
DESIGN STEP	DESIGN CONSIDERATION

6.3.6 Design Step 5
 	
Determine & Locate Vehicle and Pedestrian Signal Heads and Accessible Pedestrian Push Buttons
	• Consider signal operations
	• Review noted information from field checklist (visibility, operations and phasing)
	• Then refer to:
	  o Signal head layouts (in Chapter 3)
	  o Standard plates and technical manual for symbols and,
	  o Uniform traffic signal plan labeling format
	• Review opposing left turn mast arm and ensure that opposing left turn heads do not block each other
	• Review Advance Warning Flasher (AWF) needs
	• Include 1 head for each high speed through lane
	• Review intersection geometry – consider vehicle paths through intersection to avoid conflicting paths
	• In the past, a 55' mast arm was the longest available. Longer Signal arms from 60' to 80' are now available and covered by standard plates 8133 and 8134.
	• The Signal Poles and APS Ped Stations include precise X, Y control points. Coordination with the ADA Design and Construction Office.



SIGNAL CONTROL POINTS

POINT NO.	X	Y	DISTANCE TO FRONT OF LANDING (FT)	DISTANCE TO BACK OF LANDING (FT)
PB8-1	555973.5471	186473.9606	2	6
PB2-2	555916.2765	186470.6450	2	6
PB2-1	555930.3865	186471.5934	9	1
PB4-2	ON POLE 3	ON POLE 3	8	2
PB4-1	555986.7955	186457.9452	1	4
PB6-2	555986.7955	186457.9452	2	7.5
PB6-1	555986.7955	186457.9452	2	4
PB8-2	ON POLE 6	ON POLE 6	2	2
POLE 1	573198.8601	253778.9766		
POLE 2	573089.5181	253699.4266		
POLE 3	573175.1256	253599.9369		
POLE 4	555986.7955	186457.9452		
POLE 5	573281.4871	253680.3494		
POLE 6	573198.8601	253778.9766		

DESIGN STEP	DESIGN CONSIDERATION
6.3.7 Design Step 6 Mast Arm Pole Standards - Base Locations A. Mast Arm & Luminaire Poles *Note: Mast arm lengths vary from 4.6 m (15') to 16.8 m (55') in 1.5 m (5') increments. When considering mast arm length, add 1.6' (i.e., when specifying a 30' mast arm, the actual dimension is 31.6' (due to plumbizer length).* *The MnDOT cell library will automatically add this length to all mast arm sizes.* *Mast arms of 60' to 80' and foundations are currently available. Check with OTST if you have a need for a longer mast arm.*  SIDE-FIRED SIGNAL	• 2 m (6.5 feet) – 3 m (10 feet) minimum clearance to pavement edge or curb [allow 0.6 m (2 feet) minimum clearance to pole mounted signals] • Check cone of visibility • Do not obstruct oncoming traffic's view of pole mounted indication • Review clearance to above ground utilities and review conflicts with underground structures (including hydraulic structures) and utilities • Should not block crosswalks, curb ramps or 1.2 m x 1.2 m (4' x 4') landing area required at the top of a pedestrian ramp and be convenient to pedestrians if push buttons are installed • Consider 1.5 m (5 foot) mast arm extensions for revision work • When inplace foundations are not identified – rule of thumb is 38 mm (1.5") anchor bolts are light duty foundations and 51 mm (2") anchor bolts are heavy duty foundations • Consider placing poles for future widening • Check if on a home moving route (consider hinges or other house moving geometric improvements) • CADD graphics are scaled appropriately for plumbizers (1.6' is added, i.e. a 30' mast arm is 31.6'). • If using twin mast arms, identify in the pole notes that the flange distances are 762 mm (30") for the mainline mast arm and 813 mm (32") for the cross street mast arm • Mast arm poles and pedestals should be located at T-intersections to help define the stop line • In the past, a 55' mast arm was the longest available (Type PA). Longer Signal arms from 60' to 80' are now available and covered by standard plates 8133 and 8134 (Type BA). • Double check windloads when using larger signs (OTST can assist with this).
B. Pedestals	• Wide Medians • Consider pedestrian path when placing pedestals which have pedestrian indications or push buttons • Consider for double lefts when length of mast arm is excessive • Compact urban intersections

DESIGN STEP	DESIGN CONSIDERATION

C. Pole Mounted Luminaires and Other Street Lighting	• Use template, check that entire intersection is lit to acceptable standard
	• Review clearance to above ground utilities
	• Check local restrictions and design standards
	• Identify metering on layout and within details
	• Check and coordinate effect on in-place or planned lighting systems
	• Locate Street Lighting
	  o Major street mast arm pole standard
	  o Additional if large intersection
	  o Mounting height 12 m (40')
	• Type (250 W HPS) @ 350o (for signing illumination)
	• Degree of placement convention is the same as pole mounted signals
	• Follow local preference for metering if DOT does not maintain or pay power for luminaires but if the DOT pays for power and maintains luminaires then meter the power source with the traffic control signal system – if not metered, a lighting feed point will need to be created
	• Consider video detection needs since video detection is generally mounted on luminaire extension

D. Preemption
 	
Refer to Section **6.3.8** (Railroad Design Guidelines) on the following page. Also refer to Chapter 11 and the MN MUTCD for additional details.
	• Railroad
	  o Coordinate work with MnDOT Office of Freight and Commercial Vehicle Operations area project manager.
	  o Special sequences for clearance
	  o Phases to operate during pre-emption
	  o Coordination with railroad – Determine timing requirements (complete railroad pre-emption timing worksheet)
	  o 2-12/C #14 from railroad bungalow to traffic signal cabinet
	  o If you have dual tracks, MnDOT Office of Freight and Commercial Vehicle Operations must ask for dual track logic.
	• EVP
	  o Note any special hub locations (standard at 6')
	  o Check horizontal/vertical alignment and consider any additional detection needed
	  o Review EVP tables to ensure single or double turret
	  o Location of confirmatory light is always on approaching leg mast arm to ensure consistency
	• Other (transit, LRT, etc.)
	• Refer to section 6.2.5.12

E. Signal Heads, Push Buttons and Bracketing	• Consider PB location and likely pedestrian path when locating median pedestals • Consider side-firing if necessary (90 degrees and 180 degrees) • Avoid pole mounting 5 section heads directly beneath the mast arm

6.3.8 Railroad Design Guidelines

Whenever a traffic signal requires interconnection between the rail road cabinet and the traffic signal cabinet to incorporate railroad preemption into the traffic control signal system, MnDOT signal design staff must coordinate with the MnDOT Office of Freight and Commercial Vehicles Operations (OFCVO) area project manager (see Chapter 11).

Any new traffic signal within 200' of the railroad track **shall** have railroad preemption (MnDOT railroad rules). Consideration for preemption should be given to any traffic signal that has the potential of queuing traffic over the tracks at distances over 200'.

MnDOTs railroad preemption design timing form will be utilized to find the advanced preemption time. The signal design manager will work with signal operations. This form and instructions can be found at:

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

Once complete, the form will be forwarded to the appropriate MnDOT OFCVO Project Manager (see map on page 11-10) for processing with the private railroad company. The railroad company will review the maximum preemption time, determining the required train detection distances to accommodate the advanced preemption time. The Railroad Company or MnDOT may recommend shortening the detector distance if the existing maximum preemption time dictates detection location may be cost prohibitive. At times, a moderate adjustment in the location of the rail detection can have a substantial cost savings. When this happens, a consensus between the railroad company, MnDOT OFCVO, District Signal Section and OTSO Signal Section will determine the location of the railroad detection or appropriate funding.

A diagnostics team should be formed consisting of representatives from the railroad company, the OFCVO manager, the district signal design manager, district signal operations, OTST design/operations and any other vested road authority. With the uniqueness and complexity of these types of traffic systems, this diagnostic team will consider any special situations and determine appropriate design/operation based on a mutual consent. This mutual consent will then be documented and filed within the intersection file.

Traffic Signal System

The following points are for the signal design project manager to consider and implement for the traffic control signal.

- Provide a completed railroad preemption design timing form to the appropriate OFCVO area project manager. The OFCVO area project manager will submit this time to the railroad company and be the primary contact with the railroad.
- 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. Some factors to be considered during this review include: geometrics of the intersection, design vehicle, volumes, turn lane capacity, free right turns and the speed limit of the tracks.

- **Strong recommendation** to design dedicated left turn lanes on all approaches, utilizing the flashing yellow arrow and the red arrow of the FYA to prohibit the left turn towards the track. If all approaches do not have dedicated left turn lanes, document why. A blank out no left turn sign may be needed to prohibit the left turn if there is a shared thru-left turn lane.
- 2-12/c #14 wires from rail road cabinet to traffic signal cabinet.
- Traffic control signal system Battery backup system is required.
- Vehicle detection between the signal stop line and tracks.
- Is detection needed on upstream far side of track? This detection will typically be required if the area between the track and the traffic signal is shorter than the design vehicle (75').

Consideration can be given to prohibit turns at existing intersections near rail crossings. If an existing intersection is evaluated and it is determined by the engineering study to not prohibit the move towards the tracks this should be documented and kept in the file.

Railroad Warning System

The following points are for the signal design project manager to confirm that the MnDOT OFCVO area project manager has implemented or considered.

- Assure appropriate advanced preemption time is designed into the rail road detection system.
- Assure the appropriate circuits are designed and terminated in the railroad cabinet.
  a) The railroad circuit shall be a double break interconnect circuit with supervision and gate down logic (gate horizontal control). See MnDOT Traffic Engineering Manual for more information.
- Rail road gates will be required for all rail road crossings interconnected to new traffic signals.
- If there are multiple mainline tracks, railroad dual track logic is required.
- Consider a "do not stop on tracks" (R8-8) sign prior to the tracks. Sign should be located on the right-hand side of the highway on either the near or far side of the grade crossing.
- Consider a "xx' between tracks and highway" (W10-11) sign prior to the track.

DESIGN STEP	DESIGN CONSIDERATION

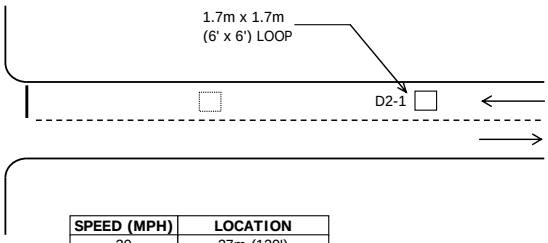
6.3.9 Design Step 7
 	
Locate Vehicle Detectors
 	
Note: The function column in the loop detector chart is not required for MnDOT projects. Some agencies may require the use of the column.
	• Locate detectors based on posted speed and signal operation
	• Consider detection technologies
	• Work with MnDOT Project Manager to determine detector technologies
	• Label protected/permissive detectors as left turn phases
	• If loop detectors:
	  ○ Create and add loop detectors chart and use detector placement charts as reference (see Chapter 4). Adjust for grade if required.
	  ○ Add function notes (if appropriate)
	  ○ Label detectors from right to left
	  ○ Specify NMC or Sawcut
	  ○ If metric plans, 6' x 6' loop should be a 1.7 m x 1.7 m loop

6.3.10 Design Step 8 Add Handholes (HH)	• Handholes for detectors only

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	6x6	5
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



SPEED (MPH)	LOCATION	OPTIONAL 2 POINT LOOP LOCATION
30	37m (120')	
35	55m (180')	
40	76m (250')	
45	92m (300')	46m (150')
50	122m (400')	61m (200')
55	145m (475')	75m (240')
60 *	168m (550')	84m (275')
65 *	191m (625')	96m (315')

LOCATION = DISTANCE FROM STOP BAR TO LOOP DETECTOR

* ONLY APPLY TO DIVIDED 4-LANE ROADWAY

Note: Prior plans may include a Function column. This column is not required for MnDOT projects (and is not shown in the graphic above). Some agencies may require the use of the column.

DESIGN STEP	DESIGN CONSIDERATION

6.3.11 Design Step 9
 	
Add Conduit Runs and Intermediate Handholes
	• HH at SOP and/or equipment pad
	• Place HH in line with each other and keep perpendicular to alignment (directional boring issues)
	• Whenever possible, do not place handholes in the public access route (PAR) or maintenance access route (MAR)
	• 2 HH's at cabinet for signal wiring and include conduit connecting these for luminaire wiring
	• HH near each pole and detector
	• Place away from roadway to minimize effect of further road widening
	• HH types
	  o PVC with metal frame and cover (no ball locator)
	  o Concrete, heavy duty cover (only if necessary)
	  o Consider concrete surrounds for structural support/grade
	• Typical spacing is 90 m (300')

6.3.12 Design Step 10 Identify Pedestrian Indications & Push Buttons	• The needs identified in step 5 can now be incorporated and graphically shown • The Federal MUTCD now includes language on countdown pedestrian signals (see below)
6.3.13 Design Step 11 Complete "Controller Phasing, Pedestrian indications and Push Buttons" Diagram	• Add poles, pole numbers, pedestrian indications, push buttons and labeling • Add type R9-3a signs if appropriate (see Appendix for "2009 Standard Signs Summary")

DESIGN STEP	DESIGN CONSIDERATION
6.3.14 Design Step 12 Develop Wiring Diagram (See Chapter 7)	• Use standard wiring chart (as shown in Chapter 7) • Check voltage drop and breaker sizes – note on correct details • Show ground rod – if SOP and controller cabinet are within 2.4 m (8 feet) of each other, the ground rod is placed in the SOP cabinet, but if further than 2.4 m (8 feet) apart, each receives a ground rod • Place a ground rod from each pole in the nearest hand hole. That ground rod will be 15' in length. • Number insulated grounds in the 70's to distinguish clearly • Number interconnect cables with numbers in the 90's to distinguish clearly • EVP detection – do not splice at terminal block and therefore do not show splice on wiring diagram • Use individual 2/c #14 (loop lead-in) wired directly to the push button with no splice. • Wire luminaires individually to use 3/c #14 • Do not share conductors between indications • Use the same graphics convention within the wiring diagram as on the layout – solid lines are new construction and dashed lines are inplace • Design about 6 wires of spare conductors into each signal pole of the traffic control signal system for future maintenance, enforcement light or future operational needs • Sequentially list the numeric conductor identification numbers – as assigned in the controller – between HH's
6.3.15 Design Step 13 Size Conduits and Identify Conduits and Conductors with Leader Lines	• Use appropriate fill charts (see Chapter 7) • Use only PVC Schedule 80 (except for loop construction) • High voltage (120 V) PVC conduit runs or ped station runs require a ground wire • Minimum 4" under road • Use 35% fill for PVC or HDPE
6.3.16 Design Step 14 Determine Mast Arm and Pole Sign Requirements	• R 10 Series • Remember to use R 10-12 signs with mast arm mounted 5-section signal heads • "D" Type • Street names • Route directional – see signing engineer • Determine pole mounted directional signing needs and determine how to address within project

DESIGN STEP	DESIGN CONSIDERATION
6.3.17 Design Step 15 Select Mast Arm Pole Foundations	• For nominal loadings, the following may be used: Type — Mast Arm Length PA85 — 15’ (4.6 m) – 30’ (9.1 m) PA90 — 30’ (9.1 m) – 40’ (12.2 m) PA100 — 40’ (12.2 m) – 55’ (16.8 m) BA60 — 60’ (18.3 m) BA65 — 65’ (19.8 m) BA70 — 70’ (21.3 m) BA75 — 75’ (22.9 m) BA80 — 80’ (24.4 m) • The type BA60 to BA80 were recently added • For unusual loading, i.e., extra or large heads, extra or large signs or 80 mph (130 km/hr) wind areas, or doubt, run the wind load program and contact Jerry Kotzenmacher at 651-234-7054. • If refurbished materials are used, designer must work with MnDOT PM • If using MnDOT standards, check with the Office of Traffic Engineering • For non-MnDOT projects work with the manufacturer to determine
6.3.18 Design Step 16 Signal Head Chart	• Identify LED indications • Graphics – keep clear (Use appropriate graphics, open symbols if in-place and filled symbols if new) • Identify size – 300 mm (12”) • Include protected/permissive head phasing chart if needed • Ensure all heads shown graphically are listed in the chart

6.3.19 Design Step 17
 	
Signal Ops Notes
	• Review standard notes – see checklist in Chapter 5
	• Do not use FYA operation if:
	  ○ Intersection geometrics creates a conflicting left turn path.
	  ○ The mainline left turner has limited sight distance as defined in the current AASHTO “A Policy on Geometric Design of Highways in Streets.”

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

SIGNAL SYSTEM OPERATION

- THE SIGNAL SYSTEM FLASH MODE IS ALL RED.
- NORMAL OPERATION IS 8 PHASE, WITH PHASES 1, 3, 5, AND 7 BEING FLASHING YELLOW ARROWS BY TIME OF DAY.
- PHASES 2 AND 6 SHALL BE ON VEHICLE RECALL.

DESIGN STEP	DESIGN CONSIDERATION
6.3.20 Design Step 18 Pole Notes	• Use standard format for notes – see checklist in chapter 5 • Review pole signing needs (R series and Type D signs) • Identify orientation of pole mounted heads using the mast arm as 0 degrees and considering a full rotation around the pole 360 degrees in a clockwise direction • Mid mast arm mounts are placed according to graphic. If something else is necessary – contact the manufacturer for mounting options (for strap-on or bolt through) • Straight mount bracket is used mid mast arm • Angled mount bracket is used on the pole and end of mast arm • Angled mounts are reversible for either side of the pole • Top of angle mount will get a cap and bottom will be mounted to ped head (refer to Pole Mount Detail sheet, 11” x 17” copy included in Chapter 12)
6.3.21 Design Step 19 Equipment Pad Notes	Refer to checklist in Chapter 5
6.3.22 Design Step 20 SOP Notes	• Refer to checklist in Chapter 5 • Ensure that wood pole (if needed) is clearly shown in the plan as provided within the contract (F and I or only I) or is furnished and installed by the power company

6.3.23 Design Step 21
 	
HH to HH Conduit and Cable
	• Route conduit
	• Conduit types
	  ○ Rigid steel (RSC)
	  ○ Non-metallic (Rigid PVC or HDPE)
	• Size
	  ○ 103 mm (4”) from cabinet
	  ○ Use 103 mm (4”) under roadways
	  ○ 41 mm (1.5”) minimum for detector leads
	• Interconnect (consider fiber)

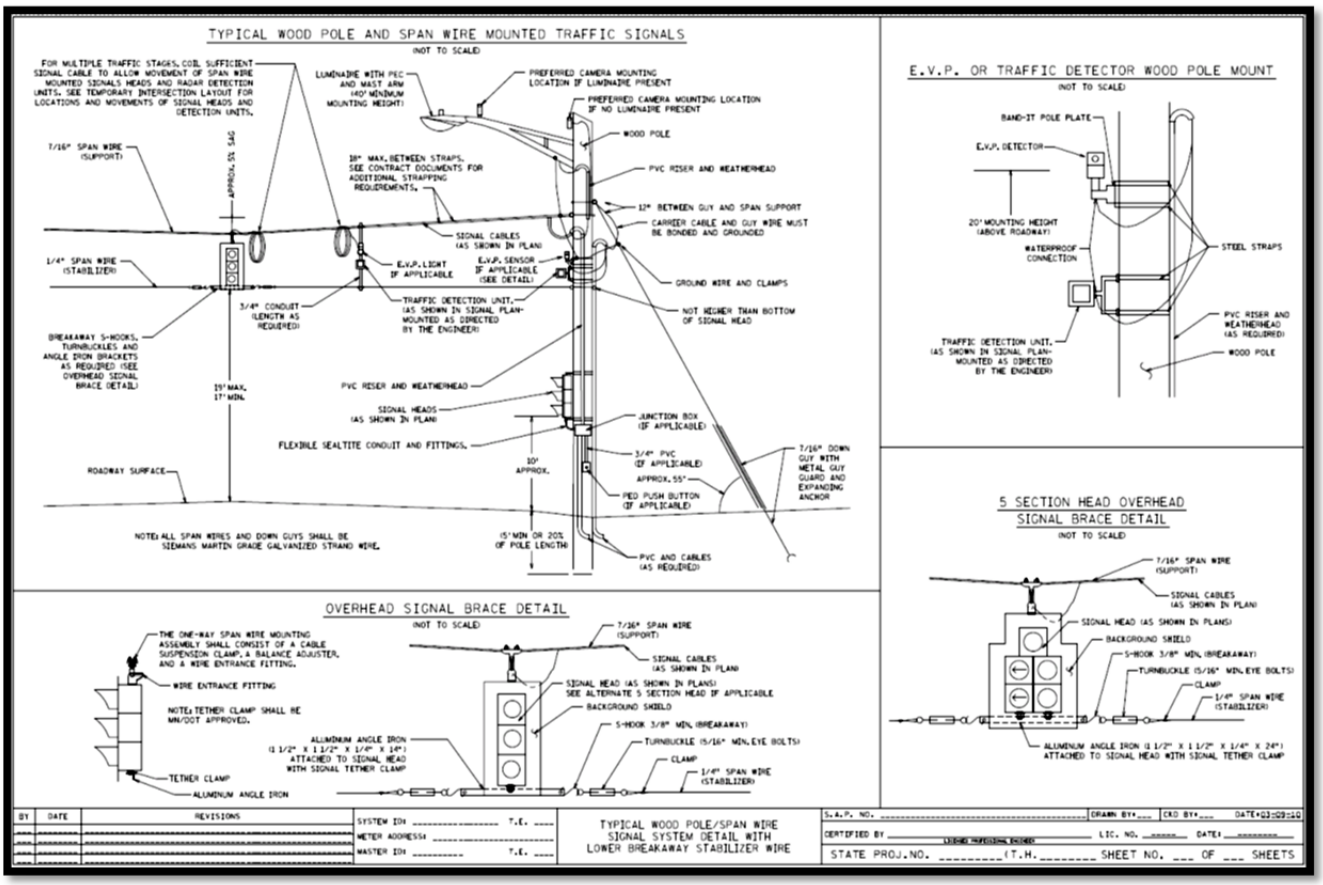
6.3.24 Design Step 22 General Construction Notes	• Refer to checklist in Chapter 5

DESIGN STEP	DESIGN CONSIDERATION
6.3.25 Design Step 23 Add Other Layouts, Notes, Charts, Etc. as Needed	
6.3.26 Design Step 24 Detail Sheets as Necessary	• Review bridge connection details with bridge office • Review and modify for specific project
6.3.27 Design Step 25 Interconnect Elements	• Show interconnect system elements within the limits of the traffic control signal system layout on the traffic control signal system layout • Ensure that items for interconnect system on traffic control signal system layout match items shown on interconnect layout • Label items on traffic control signal system layout, which are part of the interconnect system, clearly to facilitate bidding
6.3.28 Design Step 26 Complete Utility Sheets	• Graphics and tabulation complete with all notes • Coordinate 90-day utility confirmation timeline • Check conflict with any hydraulic structures (in-place or being placed) • Add general notes as appropriate
6.3.29 Design Step 27 Check Plan Completely	• Refer to the checklist in chapter 5

6.4 SPECIAL SITUATIONS

DESIGN STEP	DESIGN CONSIDERATION
6.4.1 Design Step 1 Revisions to Existing Traffic Signals	• Ensure new wire labeling is clear • Ensure phasing and pole and HH numbering conforms to current standards, LED, international peds • Clearly define what is to be done and contractor required work is clear (such as re-labeling system components for phasing changes and phasing standards) • Review bracketing revisions for standard updates • Ensure that existing items are clearly defined as existing items. • Identify portions of existing to be retained • How to remove/salvage/re-install existing and add new should be clear • Careful delineation on plans of revisions to existing signal(s) • Review wiring • Change controller and cabinet? SOP? • Temporary operations required? • Consider lead based paint removal and the requirement involved in painting (consider OSHA requirements and EPA for removal) • Consider mast arm extensions • Consider strap on heads • Review controller equipment when adding EVP - new controller may be necessary and will be included in cost agreement as state furnished materials. New cabinets are also occasionally required for EVP installations • Check in the field, and note on the plan within pole notes, the flange distances for any inplace or new twin mast arm installations. Usually distances are 813 mm/813 mm (32"/32") or 762 mm/813 mm (30"/32") • If replacing English pedestrian heads with international pedestrian heads, review the bracket spacing. The existing bracketing may conflict with the new hinge housing. A nipple extension may be needed and would then need to be identified in the contract • Consider new head bracketing when replacing a head • Ensure that revised graphics and notes clearly reflect the conditions after the revision • With existing signal, you may need to continue to use pipe bracketing since hub locations are different for straight mount and angled mount. • If pedestrian indications are changed, countdown heads are required. • Refer back to the FYA retrofit sheets (Section **2.3.5** on page **2-10**)

DESIGN STEP	DESIGN CONSIDERATION
6.4.2 Design Step 2 Wood Pole, Span Wire Systems	• Special details and layout • Overhead wiring • Review pedestrian requirements for temporary signals with local agencies • Special provisions o UV resistant cable
6.4.3 Design Step 3 Other Traffic Signals	• Lane use control • Freeway ramp metering • Movable bridges • One-lane two-way roadways • Portable signals



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7. ELECTRICAL DISTRIBUTION

7.1 GENERAL

The purpose of this chapter is to familiarize the designer with the National Electric Code (NEC) and MnDOT Standard Practices for electrical distribution above and below ground for traffic control signal systems.

Voltage is the difference of electrical potential between two points of an electrical or electronic circuit, expressed in volts. It measures the potential energy of an electric field to cause an electric current in an electrical conductor.

The following are typical voltage rates:

- Vehicle and Pedestrian Signal - 120 V AC
- Pedestrian Push Button - 24 V DC
- Highway Lighting - 120 V or 240 V AC

7.2 ELECTRICAL DISTRIBUTION

7.2.1 Wire Gauge

American wire gauge (AWG) is a standardized wire gauge system used in the United States and other countries, especially for nonferrous, electrically conducting wire.

Increasing gauge numbers give decreasing wire diameters, which is similar to many other non-metric gauging systems. This seemingly-counterintuitive numbering is derived from the fact that the gauge number is related to the number of drawing operations that must be used to produce a given gauge of wire; very fine wire (for example, 30 gauge) requires far more passes through the drawing dies than does 0 gauge wire.

Note that for gauges 5 through about 14, the wire gauge is effectively the number of bare solid wires that, when placed side by side, span 1 inch. That is, 8 gauge is about 1/8 inches in diameter.

Not to Scale

An AWG of 14 is the standard for MnDOT traffic control signal systems.

For MnDOT Traffic control signal systems:

- New cables will now be 3, 4, 6 and 12 conductor typical.
- 12 conductor wire should be the most common cable from the cabinet to the pole base. Leave plenty of spares.
- 3 conductor cable can only be used for the luminiare, EVP confirmation light and flasher. All three wires are to be used. The splice dot on the middle wire will be left open on the wiring diagram. (see example plan in Chapter 12)
- Due to the wire color and meeting code requirements, the 3 conductor cable can not be used for the pedestrian indications.

- When a 5 section indication is used, the yellow and green arrows will match color orange and blue, thus leaving the red/black wire as spare. (See example plan)
- 4" conduit is the minimum size conduit under a roadway.
- Reduced diameter cable is no longer used. The same type of 3, 4 and 6 connector cable used from the cabinet to the base will be used from the base to the component.
- Neutrals can no longer be shared.

Ground rod symbol within the hand hole will have 2 or 3 lines (end run will have 2 lines), pointed in the direction the wire runs. (See example plan)

7.2.2 Compliance with Electrical Codes and Standards

The National Electrical Code (NEC) 2014 edition and the National Electrical Code handbook (current edition) cover the following:

- Color of Insulation
- Voltage Drop
- Insulation
- 40% Fill (MnDOT uses 35% fill for NMC or HDPE)
- Junction Box Sizing

Additional details can be found at www.necdirect.org.

7.2.2.1 Article 344 - Rigid Metal Conduit (NEC)

Number of Conductors in Conduit

The electrical wiring between the signal cabinet and the poles or pedestals usually travels in underground conduit. Conduit is usually rigid steel conduit (RSC) or non-metallic conduit (NMC OR HDPE) whose size is determined by the application and the number of cables that it must accommodate. Conduits shall be filled to no more than forty percent (40%) by area (see tables on the following page).

For NMC OR HDPE, MnDOT used thirty-five percent (35%) fill by area.

7.2.3 Dimensions of Conduit

The following table shows the dimensions of conduit for traffic signal installations.

Exhibit 7-1 Dimensions of Conduit

Trade Size (mm)	Trade Size Inches	Rigid PVC Schedule 40 NMC (RNC)			Rigid PVC Schedule 80 NMC (RNC) and Schedule 80 HDPE NMC		
		Inside Diameter (In.)	Area (Sq. In.)	35% (Sq. In.)	Inside Diameter (In.)	Area (Sq. In.)	35% (Sq. In.)
41	**1-1/2**	1.624	2.070	**0.725**	1.476	1.710	**0.599**
53	**2**	2.083	3.406	**1.192**	1.913	2.873	**1.005**
63	**2/1/2**	2.489	4.863	**1.702**	2.290	4.117	**1.441**
78	**3**	3.090	7.495	**2.623**	2.864	6.439	**2.254**
103	**4**	4.050	12.876	**4.507**	3.786	11.252	**3.938**
129	**5**	5.073	20.202	**7.071**	4.768	17.846	**6.246**

7.2.4 Dimensions of Cable

The following table shows the dimensions of cable used for traffic signal installations.

Exhibit 7-2 Dimensions of Cable

Type of Wire	Diameter (Inches)	Area (Sq. In.)	Name
2/c#14 (loop lead-in)	0.36	0.102	Loop lead-in
4/c#18	0.33	0.085	Microwave and sonic detection cable
4/c#14	0.45	0.159	Signal control cable
3/c#20	0.30	0.071	EVP detector cable
3/c#12	0.45	0.159	Signal control cable
3/c#14	0.40	0.126	Signal control cable
5/c#12	0.53	0.221	Signal control cable
6/c#14	0.53	0.221	Signal control cable
12/c#12	0.79	0.490	Signal control cable
12/c#14	0.710	0.396	Signal control cable
6Pr#19	0.55	0.237	Telephone cable
No. 3/0	0.67	0.352	Power conductors
No. 2/0	0.59	0.273	Power conductors
No.1/0	0.55	0.237	Power conductors
No.1	0.51	0.204	Power conductors
No. 2	0.43	0.145	Power conductors
No. 4	0.35	0.096	Power conductors
No. 6	0.30	0.071	Power conductors
No. 6 stranded/insulated	0.30	0.071	Grounding conductor
No. 6 Bare	0.16	0.020	Grounding conductor
No. 8	0.28	0.062	Power conductors
No. 10	0.20	0.031	Power conductors

Minimum Rating and Size (NEC)

(b) Ampacity relative to service entrance conductors

(FPN No. 2): Conductors for feeders as defined in Article 100, sized to prevent a voltage drop exceeding 3 percent at the farthest outlet of power, heating and lighting loads

7.2.5 Utility Clearances

The following are the minimum overhead utility clearances:

Exhibit 7-3 Overhead Utility Clearances

Voltage	0 - 750 V	750 V - 50 kV
Horizontal Clearance	1.5 m (5’)	3 m (10’) Radius
Vertical Clearance	1.8 m (6’)	3 m (10’) Radius

Check with the power company for other minimum requirements.

7.2.6 Suggested Standard Electrical Junction Box Sizes on Bridges

Traffic Signal Junction Boxes

12” x 12” x 8” ID: conduit size is 2”.

24” x 24” x 8” ID: conduit size is 3” or 4”.

Lighting System Junction Boxes

Wallpack j-boxes (largest conduit is 1”)

8 ½” x 8 ½” x 4” ID: Minimum Size allowed as per MnDOT Spec Book (3838.2B)

Boxes where conductors are #6 or smaller and conduit is larger than 1”.

12” x 12” x 8” ID: conduit size is 2”.

24” x 24” x 8” ID: conduit size is 3” or 4”.

Straight Pulls - Use 8 times the largest conduit size if conductors are #4 or larger)

16” X 16” X 8”: conduit size is 2”

24” X 24” X 8”: conduit size is 3”

32” X 32” X 8”: conduit size is 4”

Angle Pulls or where there are splices - Use 6 times the largest conduit size where conductors are #4 or larger.

12” X 12” X 8”: conduit size is 2”

18” X 18” X 8”: conduit size is 3”

24” X 24” X 8”: conduit size is 4”

Notes

The above standard sizes are based on cubic inches to allow for the number of wires, on conduit size to allow cable pulling and routing space, and to meet the requirements of the National Electrical Code (NEC).

These are based on the most common situations and selected from the standard sizes available from manufacturers. Standard sizes available from manufacturers range from 4” x 4” x 3” to 36” x 36” x 12”.

Loop splice kits and lighting cable splices were also considered in the cubic inch measurement.

In addition all junction boxes should meet current MnDOT specs and the current NEC requirements.

7.2.7 National Electrical Code Requirements that Apply to Box Sizing

Article 314.16:

For conductors size #6 and smaller and cables containing # 6 and smaller conductors. This section requires that boxes meet a volume in cubic inches based on the sizes of individual conductors. (#14 wire = 2 cu in each) *This section applies mostly to signals because all the conductors are #6 or smaller except for service laterals.*

Article 314.28:

For conductors size #4 and larger and cables containing # 4 and larger conductors. This section requires box sizing to be based on the sizes and number of conduits connected to a box.

This section applies mostly to lighting because we use #4 or larger conductors except where feeding wall packs.

There are two conditions listed in this section; straight pulls and angle pulls.

For straight pulls the box length required to be 8 times the size of the largest conduit.

For angle pulls the box length required to be 6 times the size of the largest conduit.

7.3 VOLTAGE DROPS

The voltage drop of a circuit is in direct proportion to the resistance of the conductor and the magnitude of the current. If you increase the length of a conductor, you increase its resistance—and you thus increase its voltage drop. If you increase the current, you increase the conductor voltage drop. Thus long runs often produce voltage drops that exceed NEC recommendations.

The NEC recommends that the maximum combined voltage drop for both the feeder and branch circuit should not exceed five percent, and the maximum on the feeder or branch circuit should not exceed three percent. This recommendation is a performance issue, not a safety issue.

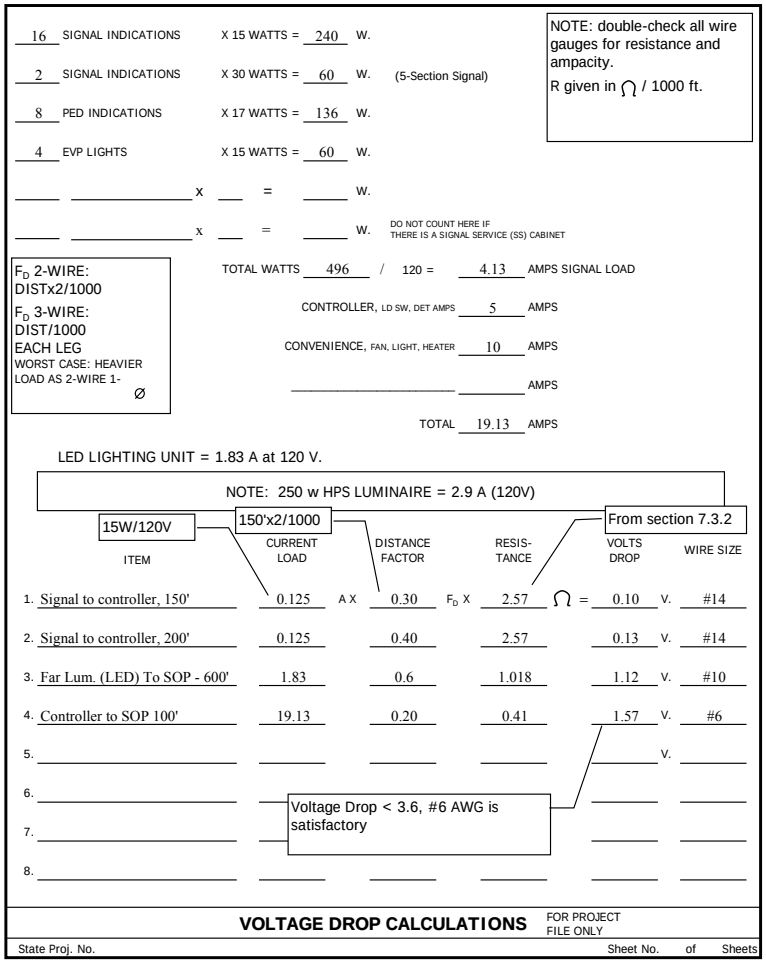
7.3.1 Voltage Drop Calculations

Maximum Resistance = Line voltage x allowed % drop ÷ current x distance factor

L = Length of wire in meters (vertical + horizontal)

For an LED Signal Indication 12" Signal Lamp:

15 watts/120 volts = 0.125 amps


16 SIGNAL INDICATIONS X 15 WATTS = 240 W.
2 SIGNAL INDICATIONS X 30 WATTS = 60 W. (5-Section Signal)
8 PED INDICATIONS X 17 WATTS = 136 W.
4 EVP LIGHTS X 15 WATTS = 60 W.
x = W.
x = W. DO NOT COUNT HERE IF THERE IS A SIGNAL SERVICE (SS) CABINET
NOTE: double-check all wire gauges for resistance and ampacity.
R given in Ω / 1000 ft.
F_D 2-WIRE: DISTx2/1000
F_D 3-WIRE: DIST/1000 EACH LEG
WORST CASE: HEAVIER LOAD AS 2-WIRE 1-Ø
TOTAL WATTS 496 / 120 = 4.13 AMPS SIGNAL LOAD
CONTROLLER, LD SW, DET AMPS 5 AMPS
CONVENIENCE, FAN, LIGHT, HEATER 10 AMPS
AMPS
TOTAL 19.13 AMPS
LED LIGHTING UNIT = 1.83 A at 120 V.
NOTE: 250 w HPS LUMINAIRE = 2.9 A (120V)
15W/120V
150'x2/1000
From section 7.3.2
ITEM | CURRENT LOAD | DISTANCE FACTOR | RESIS-TANCE | VOLTS DROP | WIRE SIZE
1. Signal to controller, 150' | 0.125 A X | 0.30 F_D X | 2.57 Ω = | 0.10 V. | #14
2. Signal to controller, 200' | 0.125 | 0.40 | 2.57 | 0.13 V. | #14
3. Far Lum. (LED) To SOP - 600' | 1.83 | 0.6 | 1.018 | 1.12 V. | #10
4. Controller to SOP 100' | 19.13 | 0.20 | 0.41 | 1.57 V. | #6
5. V.
6.
7.
8.
Voltage Drop < 3.6, #6 AWG is satisfactory
VOLTAGE DROP CALCULATIONS
FOR PROJECT FILE ONLY
State Proj. No. Sheet No. of Sheets

For a branch, the maximum voltage drop is 120 volts x 3% allowable maximum = 3.6 volts maximum voltage drop.

How To Do Voltage Drops:

- Fill in the numbers of indications, etc. A four- or five-section signal head is counted as 30 watts.
- Figure total watts, then amps.
- On a typical signal (with no signal service cabinet) where the controller is fed from pole-mounted service equipment, use the TOTAL AMPS line as signal load. If there is a Signal Service (SS) cabinet and separate circuits, loads must be split.

Distance Factors: Read the distance from the plans. Figure the factor. Plug it into the formula on each line.

Resistance and Ampacities: from standard tables on page 7-8.

Exhibit 7-4 Voltage Drop Calculation Worksheet

NOTE: double-check all wire gauges for resistance and ampacity.
R given in Ω / 1000 ft.

_____ SIGNAL INDICATIONS X 15 WATTS = _____ W.

_____ SIGNAL INDICATIONS X 30 WATTS = _____ W. (5-Section Signal)

_____ PED INDICATIONS X 17 WATTS = _____ W.

_____ EVP LIGHTS X 15 WATTS = _____ W.

_____ _____ X ____ WATTS = _____ W.

_____ _____ X ____ WATTS = _____ W. DO NOT COUNT HERE IF THERE IS A SIGNAL SERVICE (SS) CABINET

F_D 2-WIRE:
DISTx2/1000
F_D 3-WIRE:
DIST/1000
EACH LEG
WORST CASE: HEAVIER LOAD AS 2-WIRE 1-Ø

TOTAL WATTS _____ / 120 = _____ AMPS SIGNAL LOAD

CONTROLLER, LD SW, DET AMPS _____ AMPS

CONVENIENCE, FAN, LIGHT, HEATER _____ AMPS

_____ _____ AMPS

TOTAL _____ AMPS

LED LIGHTING UNIT = 1.83 A at 120 V.

NOTE: 250 w HPS LUMINAIRE = 2.9 A (120V)

	ITEM	CURRENT LOAD		DISTANCE FACTOR		RESIS-TANCE		VOLTS DROP	WIRE SIZE
1.	_____	_____	A X	_____	F_D X	_____	Ω =	_____ V.	_____
2.	_____	_____		_____		_____		_____ V.	_____
3.	_____	_____		_____		_____		_____ V.	_____
4.	_____	_____		_____		_____		_____ V.	_____
5.	_____	_____		_____		_____		_____ V.	_____
6.	_____	_____		_____		_____		_____	_____
7.	_____	_____		_____		_____		_____	_____
8.	_____	_____		_____		_____		_____	_____

VOLTAGE DROP CALCULATIONS FOR PROJECT FILE ONLY

State Proj. No. Sheet No. of Sheets

Exhibit 7-5 Electrical Wire Characteristics (Dual Units)

AWG	Resistance of Copper Wire		Ampacity THW Amps	Resistance of Aluminum Wire	
	Ohm / 1000 Ft	Ohm / 1000m		Ohm / 1000 Ft	Ohm / 1000m
18	6.51	21.36		10.70	35.10
16	4.10	13.45		6.72	22.05
14	2.57	8.43	15	4.22	13.85
12	1.62	5.31	20	2.66	8.73
10	1.02	3.35	30	1.67	5.48
8	0.64	2.10	45	1.05	3.44
6	0.41	1.35	65	0.67	2.20
4	0.26	0.85	85	0.42	1.38
3	0.21	0.69	100	0.34	1.12
2	0.16	0.52	115	0.27	0.89
1	0.13	0.43	130	0.21	0.69
0	0.10	0.33	150	0.17	0.56
00	0.08	0.26	175	0.13	0.43
000	0.06	0.20	200	0.11	0.36

Exhibit 7-6 Wire Specification Chart

WIRE SPECIFICATION CHART		
Type	Name	Specification Number
1/C#2	Power Conductors	3815.2B.1
1/C#6	Power Conductors	3815.2B.1
1/C#6 INS.GR.	Grounding Conductors	3815.2B.5
2/C#14	Loop Detector Lead-In Cable	3815.2C.4
3/C#14	Signal Control Cable	3815.2C.3
4/C#14	Signal Control Cable	3815.2C.3
6/C#14	Signal Control Cable	3815.2C.3
12/C#14	Signal Control Cable	3815.2C.3
6PR#19	Telephone Cables Outdoor	3815.2C.6.b
3/C#20	EVP Detector Cable	3815.2C.5

Exhibit 7-7 LED Signal Head Wattages

LED Signal Head Wattages	
Red	10
Yellow	15
Green	12
Red Arrow	<= 10
Yellow Arrow	<= 22
Green Arrow	<= 12
Walk	8
Don't Walk with Countdown	17

7.3.2 Bonding and Grounding

Grounding of the signal poles shall be accomplished by bonding together the #6 AWG, stranded, insulated green grounding conductor that runs from the traffic signal cabinet to the ground rod electrode and thru to the pole base. The ground rod electrode shall be placed in the hand hole with the top of the ground rod being installed approximately 3 inches below the bottom of the hand hole cover as specified in the plans. Each pole shall include a 15' ground rod in the nearest hand hole to the pole.

Connection of the daisy chain #6 AWG stranded insulated green grounding conductor that runs from the adjacent signal poles ground rod electrode to the next signal pole's ground rod electrode shall be welded to the ground rod electrode with a T type connector utilizing a 3 wire tap connection. A 2 wire tap connection shall be utilized at the end of the daisy chain run.

Bonding of all ground rod electrodes to the #6 AWG stranded, insulated green conductor coming from the traffic signal cabinet and running to the signal pole base shall be accomplished by exothermic welding.

7.3.3 Obtaining Electrical Power from MnDOT Traffic control signal systems

Other MnDOT offices as well as non-MnDOT agencies, have tapped into MnDOT signal and lighting equipment maintained by the Office of Traffic Engineering (OTE) Electrical Services Section (ESS). On occasion this has occurred without prior authorization or notification.

After a request for power (feedpoint) has been made with the local power utility, and no other source of power is available or deemed to be too expensive, the requestor may request power from a MnDOT signal or lighting system. A traffic control signal system refers to any cabinet containing traffic signal, traffic management, or traffic recording equipment. Sharing an electrical power source with MnDOT benefits other offices and agencies, and can be accomplished without adverse effects on the efficiency or safety of the electrical system. In many cases, this type of installation will result in a substantial savings in tax payer cost when compared to establishing a separate source of electrical power. All costs incurred by the new installation shall be paid by the requestor.

In order to assure safe and efficient operation of all equipment, however, and to monitor electrical power sharing and billing, prior approval must be obtained and certain procedures must be followed.

The following procedures vary depending on what agency requests the power and the type of equipment involved.

7.3.3.1 Traffic control signal system

A traffic control signal system is defined as any cabinet containing traffic signal, traffic management, or traffic recording equipment.

The traffic control signal system refers to any cables that lead into or out of the signal cabinet. Power shall not be obtained from inside the signal cabinet. Power can be obtained from the service equipment/ service cabinet or from the unmetered lighting conductors in the signal bases. If the lighting conductors are to be used as the power source, follow the requirements for obtaining power from a lighting unit as previously stated.

1. The requestor seeking electrical power shall submit a scaled drawing, signed by a professional engineer or certified electrician, of the proposed installation to the District/Division. The drawing shall include the reason for the request as well as the intended electrical loading.

2. The appropriate District/Division will review the information with ESS, and will work with the requestor to develop an acceptable proposal.

3. The requestor shall contact the local utility company to notify them of the installation and set up a billing procedure. Documentation of this agreement shall be forwarded to the District/Division prior to the start of construction.

4. If the request is approved, the applicable requirements from the following list and the general requirements must then be fulfilled.

Requirements

- A separate circuit breaker shall be provided and labeled as to its use. Power to the circuit breaker must be obtained from the un-metered side of the load center or ahead of the meter. A separate meter may be required by the power utility.
- All additional conductors and cables shall be labeled within the MnDOT traffic control signal system.
- The installation must be inspected by ESS and the required electrical permits be obtained from the local electrical inspector to insure code compliance and safety to maintenance personnel and the public. ESS should be notified as soon as a construction date is determined.

General

- MnDOT may disconnect the system without prior notice if the installation interferes with the operation of the MnDOT system.
- If MnDOT relocates or moves the system providing power, it is the requesting office's responsibility to reconnect to MnDOT's system or to find an alternate source of power.
- The requestor shall submit as-built plan sheets, signed by a professional engineer or certified electrician, to the District/Division within 48 hours of connection into a MnDOT system.
- Only a certified electrician will be allowed access to the systems used as the power source. Prior notification must be given to ESS.
- The requesting office will be responsible for maintaining all equipment after the power source.
- The requesting office shall provide the State Lighting Engineer or appropriate District/Division and Electrical Services Section with contact information for the party who will be performing. maintenance on the system.
- The requesting office shall identify a contact person within the office.

The requesting office must be, or become, a registered owner with Gopher State One Call and be responsible for locating the cable from the MnDOT power source to the location being served.

7.4 FIELD WIRING

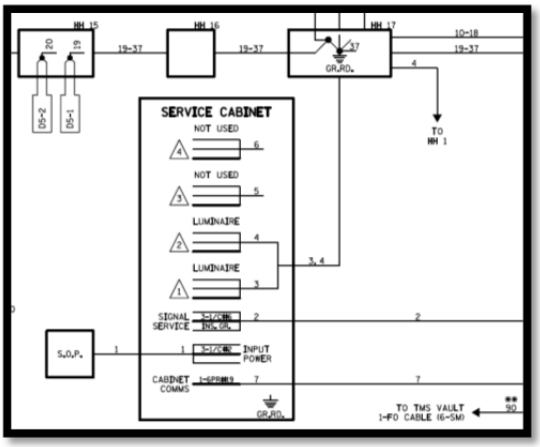
The field wiring diagram is used to describe how the actual field wiring shall be placed. Some of the issues associated with this sheet include:

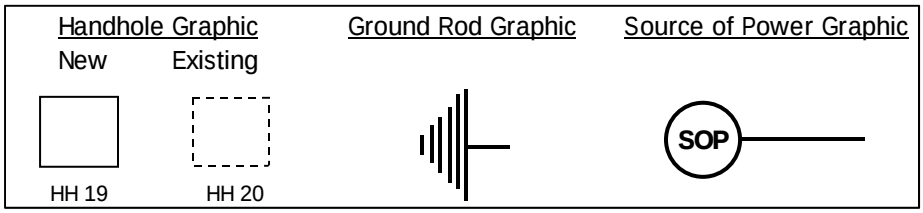
- The diagram is not to scale and is only a schematic.
- Lay out the wiring diagram in the same orientation as the intersection layout. If the traffic control signal system is laid out such that the cable runs leave the cabinet and “wrap around” the intersection, then show the cabinet in the center of the wiring diagram with cables leaving both sides of the cabinet.
- The conductor color coding block shall be shown on the connector detail.
- Use standard wiring chart (see page 7-16).

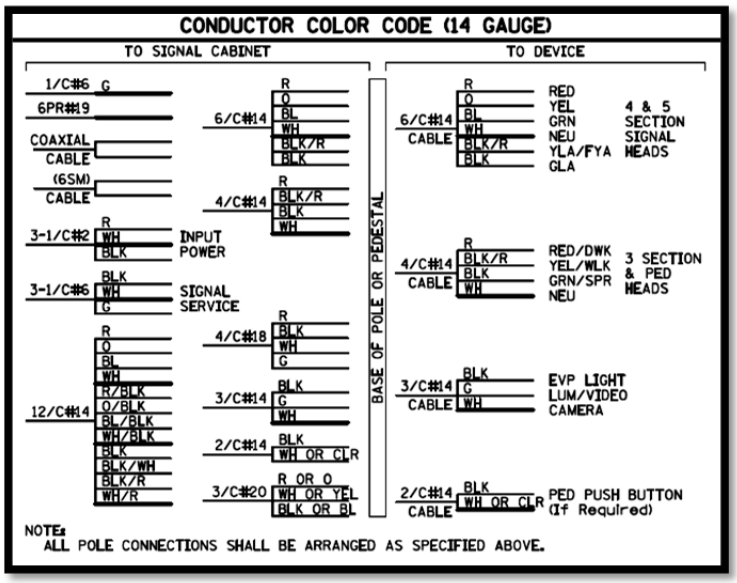
- Check voltage drop and breaker sizes – note on correct details.
- Show ground rod – if SOP and controller cabinet are within 2.44 m (8 feet) of each other, the ground rod is placed in the SOP cabinet, but if further than 2.44 m (8 feet) apart, each receives a ground rod.
- Number interconnect cables with numbers in the 90's to distinguish clearly. Write on wiring diagram where the interconnect is going to (e.g., 91 interconnect to Jones Street).
- EVP detection – do not splice in the pole base and therefore do not show splice on wiring diagram.
- Wire luminaires individually. Do not splice luminaire conductors in the pole base.
- Do not share conductors between indications.
- Use the same graphics convention within the wiring diagram as on the layout – solid lines are new construction and dashed lines are in place construction.
- Dashed lines are in place.
- Design spare conductors into the traffic control signal system for future maintenance or operation abilities (applies to vehicle and pedestrian conductors).
- Sequentially list the numeric conductor identification numbers – as assigned in the controller – between HH's.
- The wiring diagram should be easily referenced if a person is familiar with the signal layout. For example, if north is up on the plan sheet, the designer should try to make poles and HH and other structures in the northeast quadrant of the intersection end up in the upper right quadrant of the wiring diagram.
- Within the SOP cabinet detail, note whether luminaires are metered or not (text and graphic), on wiring diagram state if luminaires are metered.
- If revising a traffic control signal system, use a "key" to identify relabeled connections, new connections, new connections of existing cable, etc. (for example, * = EVP, ▲ = Existing, ■ = remove conductor, etc.).
- Main line heads should be labeled first.
- Label extra wires as spares (spr.).
- If master controller, show extra box on wiring diagram.
- Pedestrian Push Buttons will be individually wired with 2/c #14 (loop lead-in).

The graphic to the right shows a sample of the service cabinet and handholes and wiring entering the cabinet. The numbers shown on the wire graphic identify the wire number. These correspond to the number shown at the controller connection.

A solid square identifies a new handhole and a dashed square is for an existing handhole. The “HH 16” identifies the handhole number as labeled on the plan sheet.

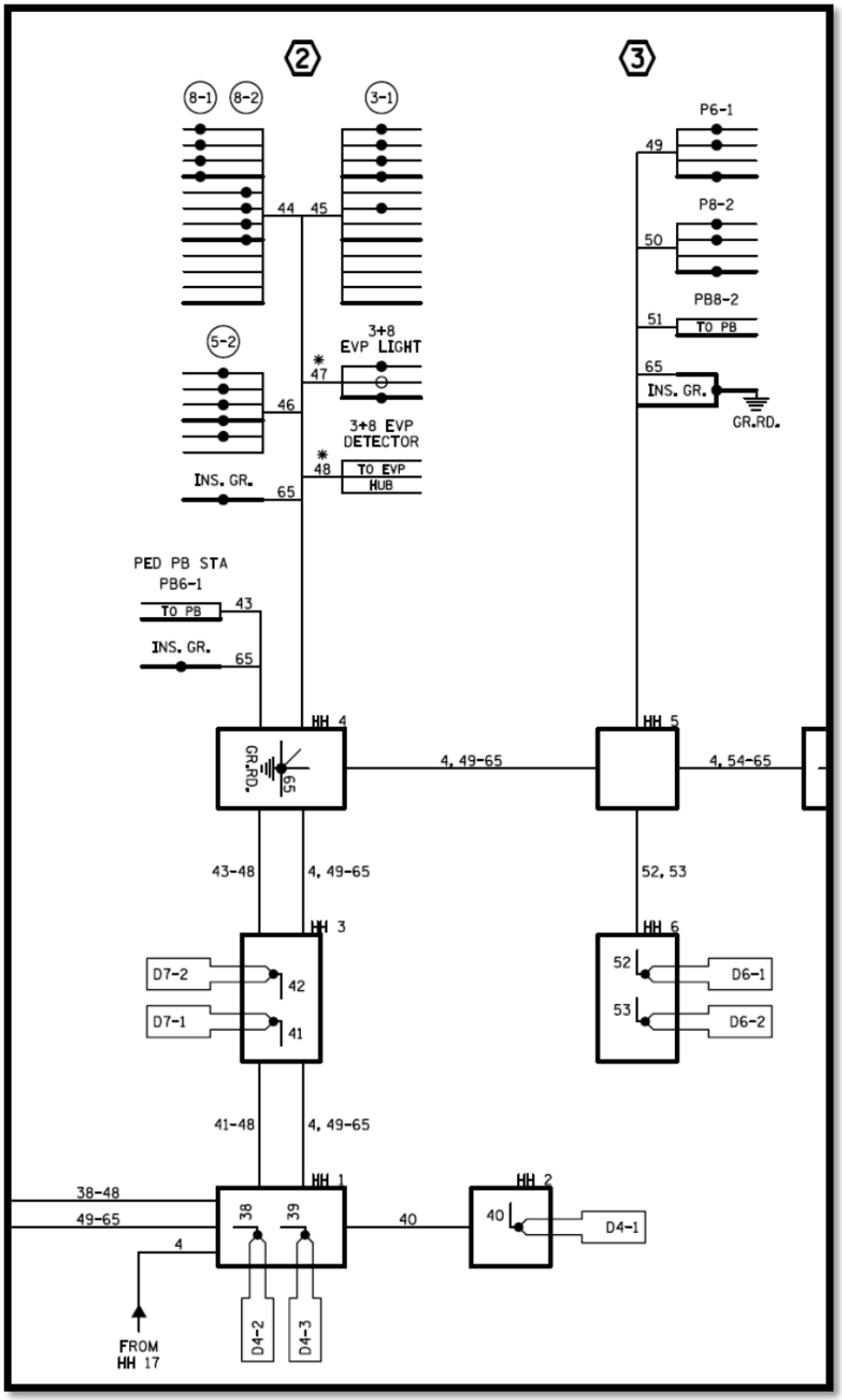




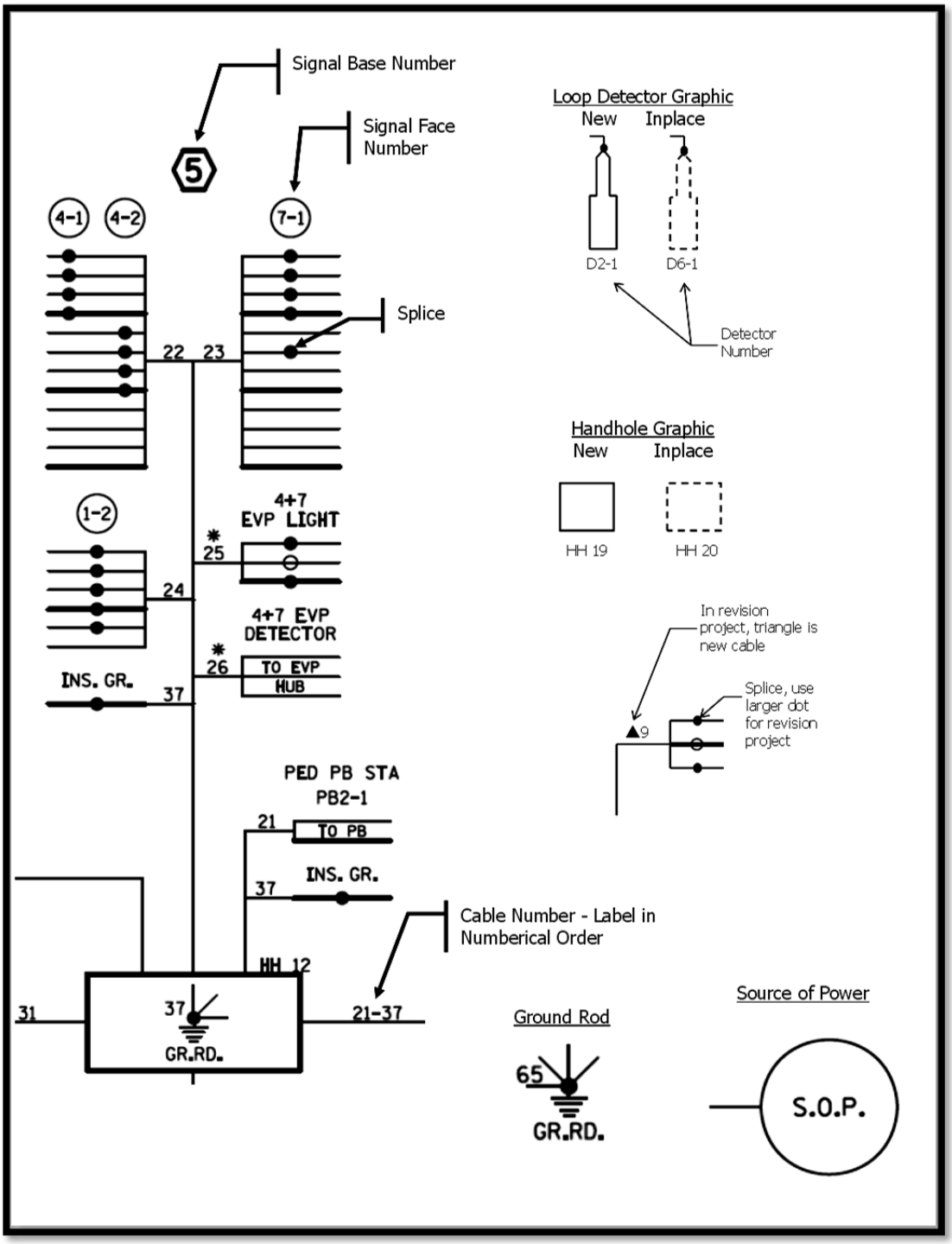


Wire Color Code Key	
R	Red
O	Orange
BL	Blue
WH	White
BLK	Black
BRN	Brown
CL	Clear
G	Green
R/BLK	Red with Black Stripe
O/BLK	Orange with Black Stripe
BL/BLK	Blue with Black Stripe
WH/BLK	White with Black Stripe
WH/R	White with Red Stripe
BLK/WH	Black with White Stripe
BLK/R	Black with Red Stripe

The number next to the cable identifies the cable number. When multilple cables are shown, they shall be listed in numerical order.

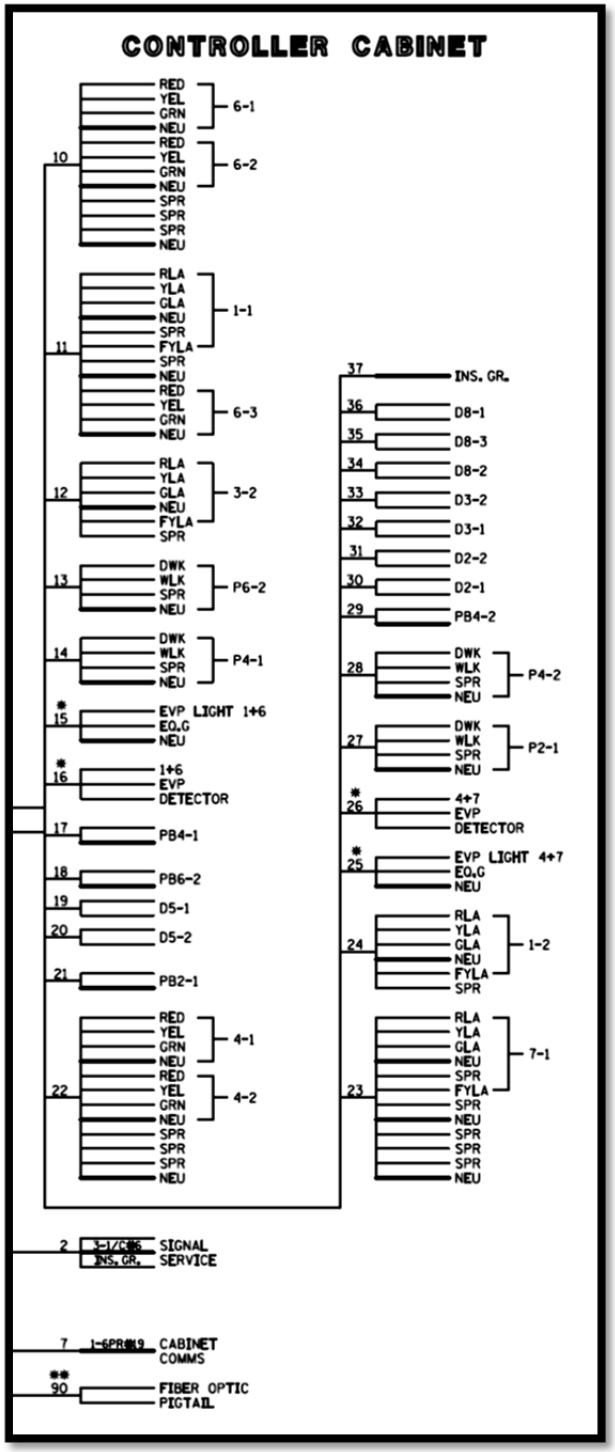


The following graphics are used on the wiring diagram.

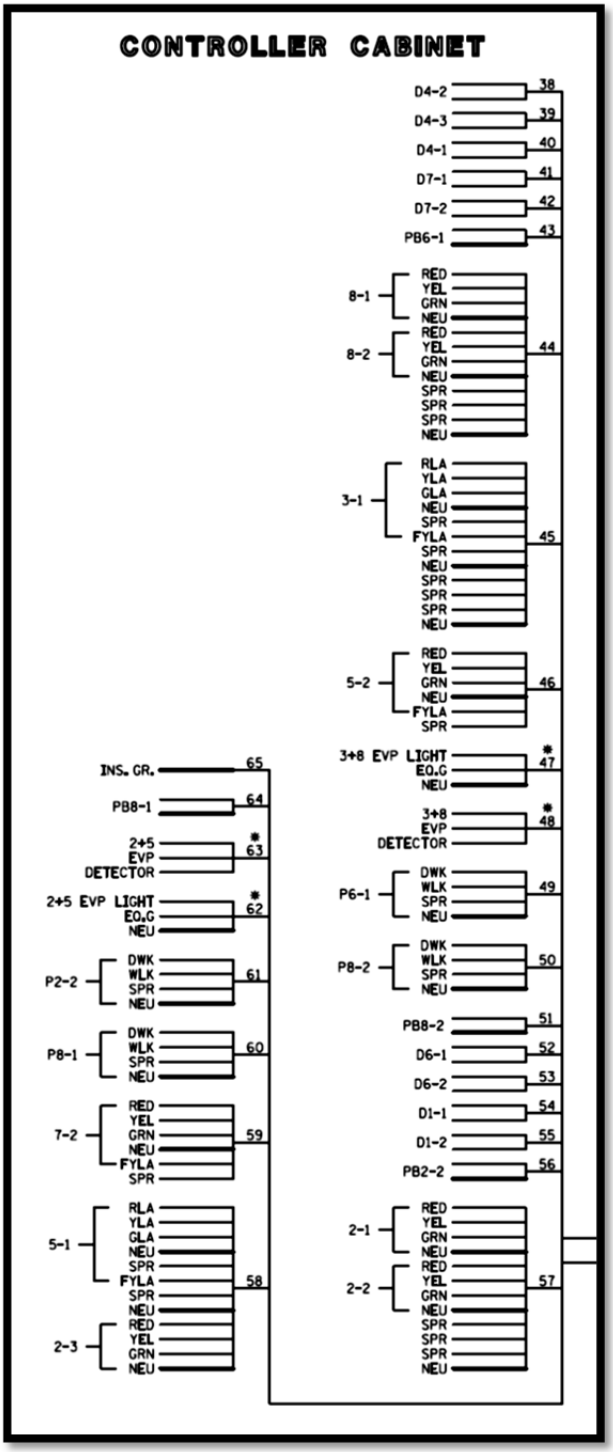


The graphic below shows a typical layout of a controller cabinet as displayed on the wiring diagram. Notice that the cables are labeling in order. Also, there are no splices in the controller cabinet.

Left Side of Cabinet (Sheet 11 of Sample Plan)



Right Side of Cabinet (Sheet 12 of Sample Plan)



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8. SIGNING AND PAVEMENT MARKINGS

8.1 GENERAL

Traffic signs and pavement markings are used to regulate, warn or guide motorists and pedestrians on all classes of public roads. The objective of this chapter is to examine the various classifications and design criteria required for the design and location of signs and pavement markings.

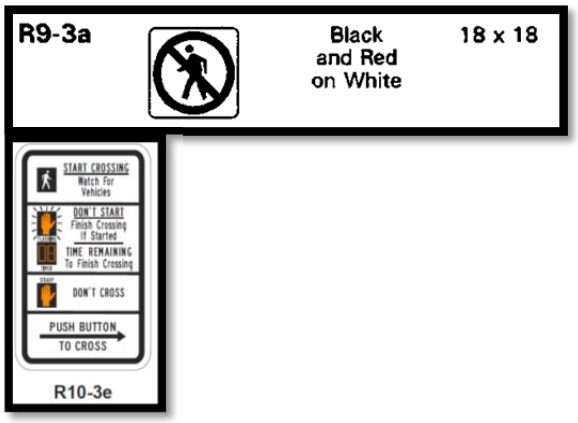
8.2 INTERSECTION SIGNING

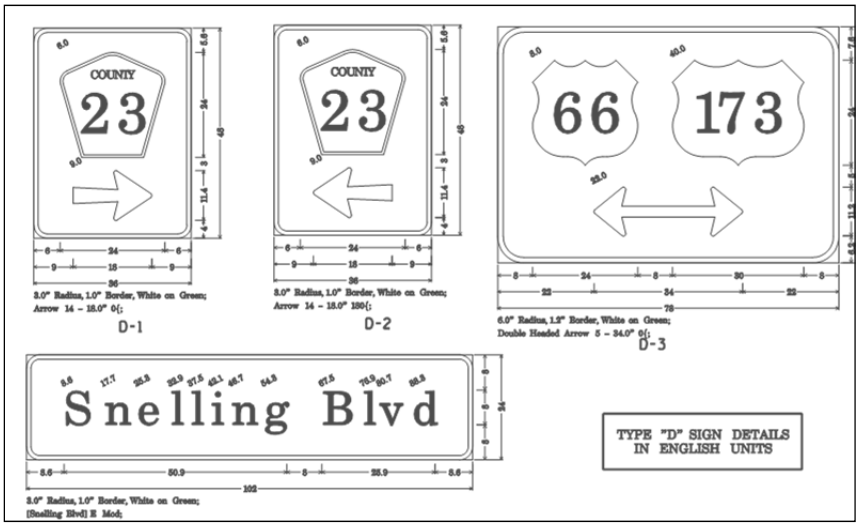
The Minnesota Manual on Uniform Traffic Control Devices (MN MUTCD) provides the legal standards for the design and use of traffic signs. Personnel responsible for the design, selection, and placement of these devices should have ready access to, and be familiar with, the MN MUTCD.

8.2.1 Classification of Signs

The following sign classifications are used with signal projects:

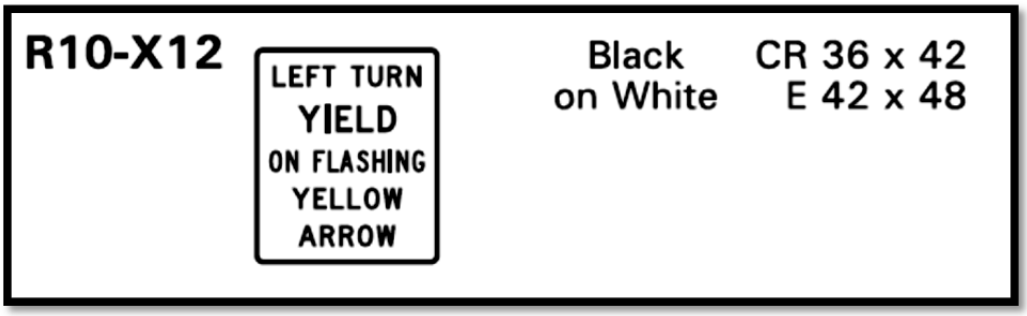
- Pedestrian "R" Series (see example to the right)
    - information sign
    - in medians
    - at corners
- Destination Type Signing
    - street names
    - route direction



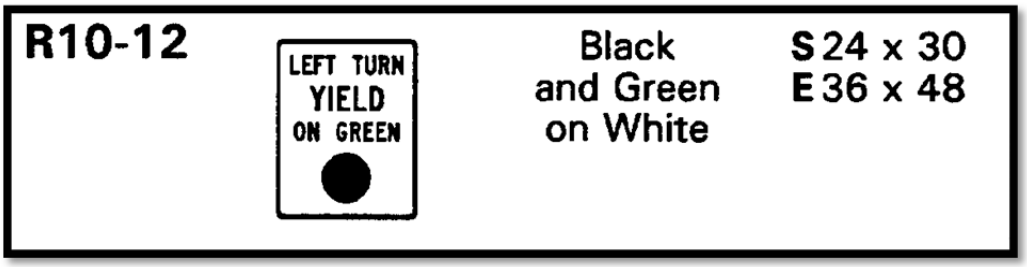


- One-way signs are occasionally placed on poles/pedestals as part of a signal project. Work with the project manager to determine specific needs.
- The designer should coordinate with the district to determine signing needs/ requirements.
- R series signs are normally incidental to the traffic control signal system.
- The plans should identify if mast arm signing is incidental to the traffic control signal system pay item.

- For FYA installations, an R10-X12 sign will be installed for a minimum of 6 months. After the 6 months, the sign can be removed by the district traffic engineer or left up for its useful life. In the Metro District, the larger 42” x 48” sign will always be used for all locations. In all other districts, use the 36’’ x 42’’ for 2-lane roadways and the 42” x 48” on a 4-lane (or more) roadway.



- The sign shown below is used when protected/permissive left turn indications are used. This sign is to be placed adjacent to the mast arm mounted head to which it applies. R10-12 signs are not placed on poles. Use the 36 x 48 on mast arms. As noted in Chapter 2, FYA installations are required for all state highways with dedicated lefts except for the exclusions listed in Technical Memorandum 12-10-T-03 (see section **2.3.3**).



- In complex signing situations, a signing layout should be considered to clarify placements.
- The mast arm graphic should be included in each signing plan sheet to use as a reference for the information being provided in the type “D” sign chart.
- An overlay chart must be included with any signing work and list the standard notes identified in the signing request sheet.

8.2.2 Dimensions

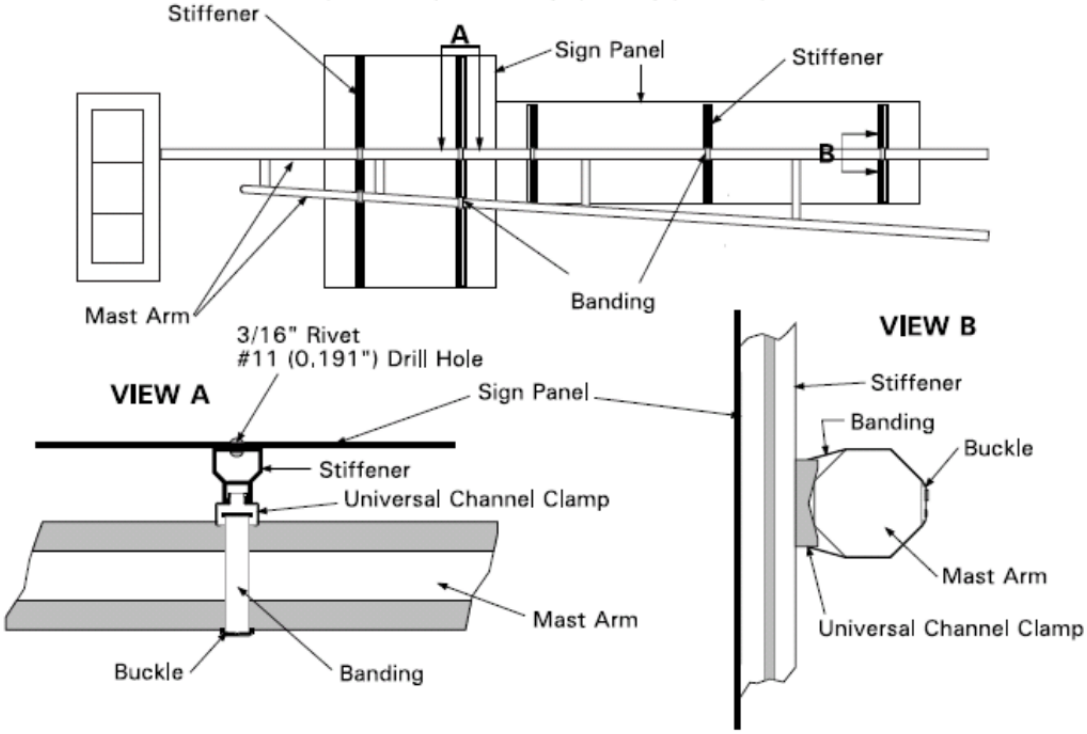
All sign dimensions are assumed to be in English units unless otherwise indicated. If the plan set is metric, the signing plan detail sheet must clearly note that the signing is in English units.

The following information should be identified for the signs used on the project:

- Width and Height
- Inches
- Feet
- Street Names (_____x_____)
- Route and Direction (_____x_____)
- Pedestrian Signs (_____x_____)

Exhibit 8-1 Typical Mast Arm Sign Mounting

TYPICAL MAST ARM SIGN MOUNTING



STIFFENER (LARGE CHANNEL EXTRUSION) REQUIREMENT TABLE

(Based on Sign Panel Dimensions in Feet)
(Where sign panel dimensions fall between one foot increments use the next highest foot length and/or height)

Height \ Length	2	3	4	5	6	7	8	9	10	11	12	13	14
2	2	2	2	3	3	3	4	4	4	5	5	5	5
3	2	2	2	3	3	3	4	4	5	5	5	5	5
4	2	2	2	3	3	3	4	4	5	5	5	5	6
5	2	2	2	3	4	4	5	5	5	5	5	5	6
6	X	X	2	3	4	4	5	5	5	5	5	5	6
7	X	X	X	4	4	5	5	5	5	5	5	5	6

NOTES:
1. Signs shall be affixed to upper and lower mast arm chords whenever possible.
2. Position bottom of sign panel 17' minimum above centerline elevation.
3. Sign panels shall be mounted plumb. Shim as required.
4. Horizontal spacing between stiffeners shall not exceed 36".
5. Horizontal inset from panel edge to stiffener shall not exceed 12".
6. Vertical inset from panel edge to stiffener shall be 0" to 0.5".
7. Rivets attaching stiffeners to sign panels shall be installed 1", on center, from the top and bottom of the panel, and then spaced no more than 6" on center.
8. The approved mounting product is the Ultra-Lok system by Bandit-Idex. Banding straps shall be 0.75" x 0.030" Type 201 (1/4 Hard) stainless steel. Banding buckles shall be Type 201 (1/4 Hard) stainless steel. Two banding straps, each with a banding buckle, shall be single-wrapped around the mast arm, clipped and tightened independently in accordance with the manufacturer's instructions. The second strap shall be installed directly over the first strap.

APPROVED	DATE OF REV.	STRUCTURAL DETAILS FOR SIGNAL MAST ARM MOUNTED SIGNS		PAGE NUMBER
8/9/02	7/6/07			105A

8.2.3 Word Message

- Use SignCAD™ software with current approved Federal alphabet.
- Font (Series C or D)
- Height of Letter Criteria
- Regular and Compressed Spacing of Message
- Request from District

8.2.4 Standardization of Location

- Mounting Height to Bottom of Sign
- Mounting Over Roadway
- Mounting Over Sidewalk/Pedestrian
- Lateral Clearance
- Structural Loading Problems

The form on the following page is used by the Metro Division to request signing.

8.2.5 MnDOT 2564.3H

For signs or sign panels being furnished and installed, the Contractor shall affix a Department furnished warning sticker to the backside of each sign panel directly above the fabrication sticker. Warning stickers are available at the Department's Transportation District Office specified in the Contract. The Transportation District's contact person and phone number are specified in the Contract. Thirty calendar days advance notice shall be given prior to picking up the stickers.

Exhibit 8-2 Signing Warning Sticker

Traffic control signal system Design – Signing Request
(Preliminary Intersection Layout(s) is Attached)

T.H. _____ at _____ S.P. _____ Letting Date: _____

Request to: _____ Request by: _____ Date: _____

TYPE "D" SIGNS								
SIGN PANEL	SIGNAL SYSTEM	POLE NO.	a (ft)	SIZE (IN)	MOUNTING BRACKET		AREA/SIGN (SQ FT)	NO. REQ.
					NO.	SPACING (1)		

(1) SPACING BETWEEN STIFFNERS SHALL NOT EXCEED 36 INCHES AND SHALL BE UNIFORMLY SPACED. SEE SPECIAL PROVISIONS FOR BRACKET SPACING REQUIREMENTS.

OVERLAYS					
CODE NO.	QUAN.	SIZE (IN.)	AREA (SQ. FT.)	TOTAL (SQ. FT.)	LEGEND

NOTES:

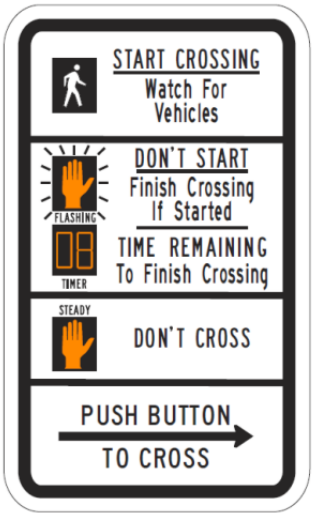
- NO. OF POSTS SPACING CAN BE DETERMINED BY SIGNAL DESIGN PERSONNEL.
- ALL SIGN DIMENSIONS ARE ASSUMED TO BE IN ENGLISH UNITS UNLESS OTHERWISE INDICATED.
- PLEASE IDENTIFY IF THE FOLLOWING TYPICAL SIGN DETAIL NOTE ARE INAPPROPRIATE:
  1. CORNERS EXTENDING BEYOND THE BORDER SHALL NOT BE TRIMMED.
  2. SEE STANDARD SIGNS MANUAL FOR ARROW AND OVERLAY DETAILS.
  3. FOR STRUCTURAL DETAILS, TYPE "D" SIGNS, SEE STANARD SIGNS MANUAL, PAGES 105A AND 105B.
  4. FOR TYPE "D" STRINGER AND PANEL JOINT DETAIL, SE STANDARD SIGNS MANUAL.
  5. FURNISHING AND INSTALLING TYPE "D" AND TYPE "R" SIGNS SHALL BE INCIDENTAL TO THE TRAFFIC CONTROL SIGNAL SYSTEM(S).

8.2.6 Pedestrian Information Sign

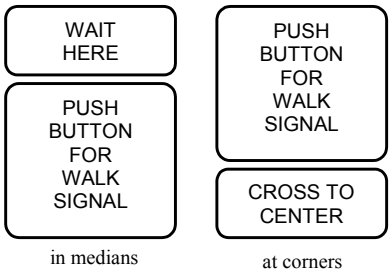
There has been increasing concern that pedestrians do not understand the pedestrian indications (WALK and DONT WALK) at traffic signals. To provide pedestrians with more information at the traffic signal and educate them as to the meaning of WALK, flashing DONT WALK and DONT WALK, the below information sign has been developed.

This sign will be available in two forms. A stick on label sign will be used to attach to traffic signal mast arm poles and an aluminum sign panel will be used on traffic signal pedestals and pedestrian push button stations.

The pedestrian informational sign shall be used on all traffic signal installations that have pedestrian indications. One sign shall be located in each corner of the intersection where pedestrian indications are located. The sign shall be located next (in close proximity) to the pedestrian push buttons or pedestrian indications. It is not necessary to install them at pedestrian push buttons or pedestrian indications located in the median. If there is an old green pedestrian information sign on the pole, remove it or place the new pedestrian information sign over the old one. **Identify this work clearly within the plan.**



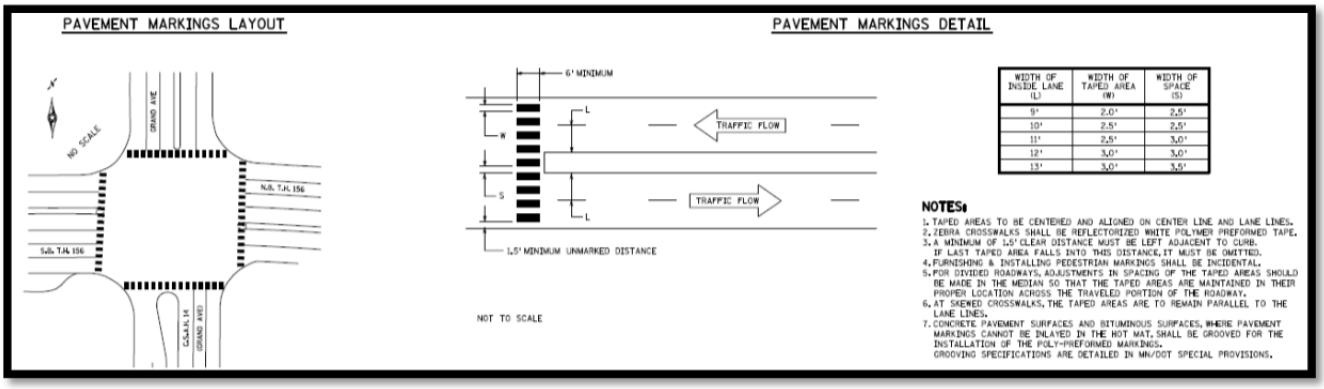
R10-3e



8.3 PAVEMENT MARKINGS

If pavement markings are part of a larger plan, include with the pavement marking page order. If the signal plan is stand-alone, lump sum with the signal plan.

8.3.1 Crosswalks and Crosswalk lines (From MnDOT Standard Plan Sheet)



WIDTH OF INSIDE LANE (L)	WIDTH OF TAPED AREA (W)	WIDTH OF SPACE (S)
9'	2.0'	2.5'
10'	2.5'	2.5'
11'	2.5'	3.0'
12'	3.0'	3.0'
13'	3.0'	3.5'

Types include perpendicular and zebra types. Below is a summary of each:

Pavement markings are to be in accordance with Standard Specifications 2582.

Perpendicular

- White In Color
- Not Less Than 150 mm (6 Inches)
- Not Less Than 1.8 m (6 Feet) Apart
- Special Circumstances Increase Up to 610 mm (24 Inches) Wide
  - Stop line not provided
  - Speeds exceed 55 km/hr (35 MPH)
- Should Extend Across Full Width of Pavement to Discourage Diagonal Walking
- Do Not Place Across Free Rights
- Contact project manager (PM) for any special concerns

Zebra

- Reflectorized White Polymer Preformed Tape
- Centered on Center Line and Lane Lines
- Adjustments Made at Median
- 3 feet (0.9 m) Wide, 6 feet (1.8 m) Long
- Keep Parallel to Roadway Alignment
- Do Not Place Across Free Rights
- Contact PM for any special concerns

The information following this sheet is a handout taken from the Minnesota Manual on Uniform Traffic Control Devices (MN MUTCD) Part 3.

The most current version of the MN MUTCD can be found at:

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

Note: It is recommended that you review all original reference material.

PART 3. MARKINGS

Chapter 3B. Pavement and Curb Markings

3B.1 Yellow Centerline Pavement Markings and Warrants

STANDARD:

Centerline pavement markings, when used, shall be the pavement markings used to delineate the separation of traffic lanes that have opposite directions of travel on a roadway and shall be yellow.

OPTION:

Centerline pavement markings may be placed at a location that is not the geometric center of the roadway.

On roadways without continuous center line pavement markings, short sections may be marked with center line pavement markings to control the position of traffic at specific locations, such as around curves, over hills, on approaches to grade crossings, at grade crossings, and at bridges.

STANDARD:

The centerline markings on two-lane, two-way roadways shall be one of the following as shown in Figure 3B-1:

A. Two-direction passing zone markings consisting of a normal broken yellow line where crossing the centerline markings for passing with care is permitted for traffic traveling in either direction;
B. One-direction no-passing zone markings consisting of a double yellow line, one of which is a normal broken yellow line and the other is a normal solid yellow line, where crossing the center line markings for passing with care is permitted for the traffic traveling adjacent to the broken line, but is prohibited for traffic traveling adjacent to the solid line; or
C. Two-direction no-passing zone markings consisting of two normal solid yellow lines where crossing the centerline markings for passing is prohibited for traffic traveling in either direction.

A single solid yellow line shall not be used as a center line marking on a two-way roadway.

The centerline markings on undivided two-way roadways with four or more lanes for moving motor vehicle traffic always available shall be the two-direction no-passing zone markings consisting of two normal solid yellow lines as shown in Figure 3B-2.

GUIDANCE:

On two-way roadways with three through lanes for moving motor vehicle traffic, two lanes should be designated for traffic in one direction by using one- or two-direction no-passing zone markings as shown in Figure 3B-3.

SUPPORT:

Sections 11-301(c) and 11-311(c) of the "Uniform Vehicle Code (UVC)" contain information regarding left turns across center line no-passing zone markings and paved medians, respectively. The UVC can be obtained from the National Committee on Uniform Traffic Laws and Ordinances at the address shown on Page i.

STANDARD:

Center line markings shall be placed on all paved urban arterials and collectors that have a traveled way of 20 feet or more in width and an ADT of 6,000 vehicles per day or greater. Center line markings shall also be placed on all paved two-way streets or highways that have three or more lanes for moving motor vehicle traffic.

GUIDANCE:

Center line markings should be placed on paved urban arterials and collectors that have a traveled way of 20 feet or more in width and an ADT of 4,000 vehicles per day or greater. Center line markings should also be placed on all rural arterials and collectors that have a traveled way of 18 feet or more in width and an ADT of 3,000 vehicles per day or greater. Center line markings should also be placed on other traveled ways where an engineering study indicates such a need.

Engineering judgment should be used in determining whether to place center line markings on traveled ways that are less than 16 feet wide because of the potential for traffic encroaching on the pavement edges, traffic being affected by parked vehicles, and traffic encroaching into the opposing traffic lane.

OPTION:

Centerline markings may be placed on other paved two-way traveled ways that are 16 feet or more in width.

If a traffic count is not available, the ADTs described in this Section may be estimates that are based on engineering judgment.

information regarding the spacing of raised pavement markers on longitudinal markings.

3B.12 Raised Pavement Markers as Vehicle Positioning Guides with Other Longitudinal Markings

OPTION:

Retroreflective or internally illuminated raised pavement markers may be used as positioning guides with longitudinal line markings without necessarily conveying information to the road user about passing or lane-use restrictions. In such applications, markers may be positioned in line with or immediately adjacent to a single line marking, or positioned between the two lines of a double center line or double lane line marking.

GUIDANCE:

The spacing for such applications should be 2N, where N equals the length of one line segment plus one gap (see Section 3B.11).

OPTION:

Where it is desired to alert the road user to changes in the travel path, such as on sharp curves or on transitions that reduce the number of lanes or that shift traffic laterally, the spacing may be reduced to N or less.

On freeways and expressways, a spacing of 3N may be used for relatively straight and level roadway segments where engineering judgment indicates that such spacing will provide adequate delineation under wet night conditions.

3B.13 Raised Pavement Markers Supplementing Other Markings

GUIDANCE:

The use of retroreflective or internally illuminated raised pavement markers for supplementing longitudinal line markings should comply with the following:

A. Lateral Positioning
   1. When supplementing double line markings, pairs of raised pavement markers placed laterally in line with or immediately outside of the two lines should be used.
   2. When supplementing wide line markings, pairs of raised pavement markers placed laterally adjacent to each other should be used.

B. Longitudinal Spacing
   1. When supplementing solid line markings, raised pavement markers at a spacing no greater than N (see Section 3B.11) should be used, except when supplementing left edge line markings, a spacing no greater than N/2 should be used.
   2. When supplementing broken line markings, a spacing no greater than 3N should be used. However, when supplementing broken line markings identifying reversible lanes, a spacing no greater than N should be used.
   3. When supplementing dotted line markings, a spacing appropriate for the application should be used.
   4. When supplementing longitudinal line markings through at-grade intersections, one raised pavement marker for each short line segment should be used.
   5. When supplementing edge line extensions through freeway interchanges, a spacing of no greater than N should be used.

Raised pavement markers should not supplement right-hand edge lines unless an engineering study or engineering judgment indicates the benefits of enhanced delineation of a curve or other location would outweigh possible impacts on bicycles using the shoulder, and the spacing of raised pavement markers on the right-hand edge is close enough to avoid misinterpretation as a broken line during wet night conditions.

OPTION:

Raised pavement markers also may be used to supplement other markings such as channelizing islands, gore areas, approaches to obstructions, or wrong-way arrows.

To improve the visibility of horizontal curves, center lines may be supplemented with retroreflective or internally illuminated raised pavement markers for the entire curved section as well as for a distance in advance of the curve that approximates 5 seconds of travel time..

3B.14 Raised Pavement Markers Substituting for Pavement Markings

OPTION:

Retroreflective or internally illuminated raised pavement markers, or nonretroreflective raised pavement markers supplemented by retroreflective or internally illuminated markers, may be substituted for markings of other types.

GUIDANCE:

If used, the pattern and color of the raised pavement markers should simulate the pattern and color of the markings for which they substitute.

OPTION:

The side of a raised pavement marker that is visible to traffic proceeding in the wrong direction may be red.

STANDARD:

If raised pavement markers are used to substitute for broken line markings, a group of three to five markers equally spaced at a distance no greater than N/8 (see Section 3B.11) shall be used. If N is other than 40 feet, the markers shall be equally spaced over the line segment length (at 1/2 points for three markers, at 1/3 points for four markers, and at 1/4 points for five markers). At least one retroreflective or internally illuminated marker per group shall be used or a retroreflective or internally illuminated marker shall be installed midway in each gap between successive groups of non retroreflective markers.

When raised pavement markers substitute for solid line markings, the markers shall be equally spaced at no greater than N/4, with retroreflective or internally illuminated units at a spacing no greater than N/2.

GUIDANCE:

Raised pavement markers should not substitute for right-hand edge line markings unless an engineering study or engineering judgment indicates the benefits of enhanced delineation of a curve or other location would outweigh possible impacts on bicycles using the shoulder, and the spacing of raised pavement markers on the right-hand edge line is close enough to avoid misinterpretation as a broken line during wet night conditions.

STANDARD:

When raised pavement markers substitute for dotted lines, they shall be spaced at no greater than N/4, with not less than one raised pavement marker per dotted line segment. At least one raised marker every N shall be retroreflective or internally illuminated.

OPTION:

When substituting for wide lines, raised pavement markers may be placed laterally adjacent to each other to simulate the width of the line.

3B.15 Transverse Markings

STANDARD:

Transverse markings, which include shoulder markings, word and symbol markings, arrows, stop lines, yield lines, crosswalk lines, speed measurement markings, speed reduction markings, speed hump markings, parking space markings, and others, shall be white unless otherwise provided in this Manual.

GUIDANCE:

Because of the low approach angle at which pavement markings are viewed, transverse lines should be proportioned to provide visibility equal to that of longitudinal lines.

3B.16 Stop and Yield Lines

GUIDANCE:

Stop lines should be used to indicate the point behind which vehicles are required to stop in compliance with a traffic control signal.

OPTION:

Stop lines may be used to indicate the point behind which vehicles are required to stop in compliance with a STOP (R1-1) sign, a Stop Here For Pedestrians (R1-5b or R1-5c) sign, or some other traffic control device that requires vehicles to stop, except YIELD signs that are not associated with passive grade crossings.

Yield lines may be used to indicate the point behind which vehicles are required to yield in compliance with a YIELD (R1-2) sign.

STANDARD:

Except as provided in Section 8B.28, stop lines shall not be used at locations where drivers are required to yield in compliance with a YIELD (R1-2) sign.

Yield lines shall not be used at locations where drivers are required to stop in compliance with a STOP (R1-1) sign, a Stop Here For Pedestrians (R1-5b or R1-5c) sign, a traffic control signal, or some other traffic control device.

Stop lines shall consist of solid white lines extending across approach lanes to indicate the point at which the stop is intended or required to be made.

Yield lines (see Figure 3B-16) shall consist of a row of solid white isosceles triangles pointing toward approaching vehicles extending across approach lanes to indicate the point at which the yield is intended or required to be made.

GUIDANCE:

Stop lines should be 12 to 24 inches wide.

The individual triangles comprising the yield line should have a base of 12 to 24 inches wide and a height equal to 1.5 times the base. The space between the triangles should be 3 to 12 inches.

If used, stop and yield lines should be placed a minimum of 4 feet in advance of the nearest crosswalk line at controlled intersections, except for yield lines at roundabouts as provided for in Section 3C.4 and at midblock crosswalks. In the absence of a marked crosswalk, the stop line or yield line should be placed at the desired stopping or yielding point, but should not be placed more than 30 feet or less than 4 feet from the nearest edge of the intersecting traveled way.

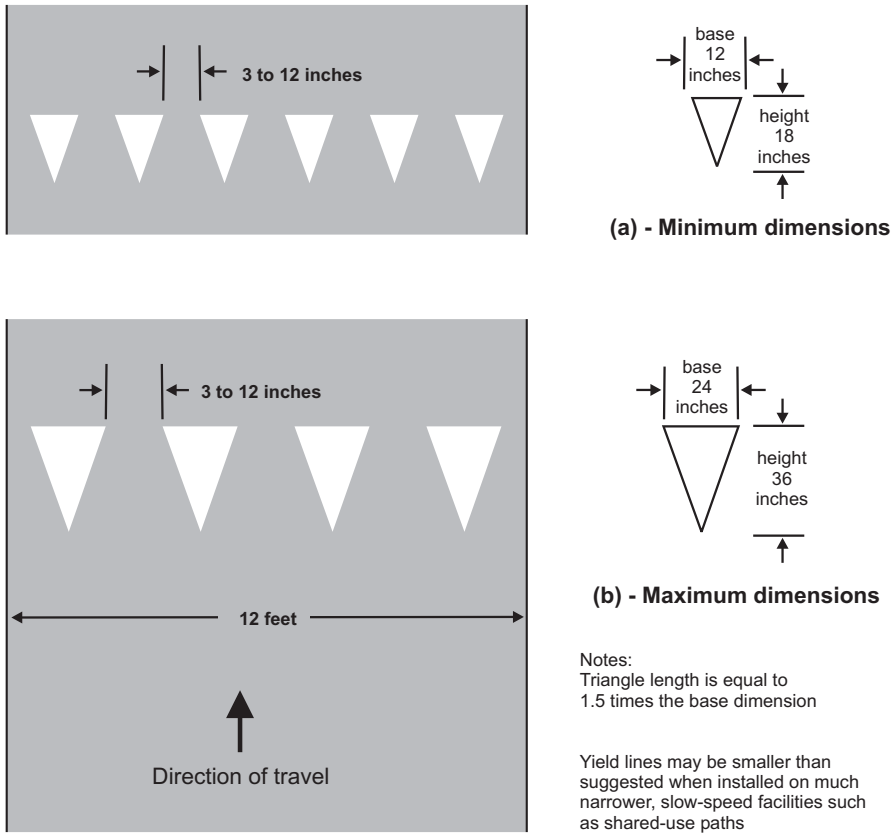


Figure 3B-16 Recommended Yield Line Layouts

Stop lines at midblock signalized locations should be placed at least 40 feet in advance of the nearest signal indication (see Section 4D.14).

If yield or stop lines are used at a crosswalk that crosses an uncontrolled multi-lane approach, the yield lines or stop lines should be placed 20 to 50 feet in advance of the nearest crosswalk line, and parking should be prohibited in the area between the yield or stop line and the crosswalk (see Figure 3B-17).

STANDARD:

If stop lines are used at a crosswalk that crosses an uncontrolled multi-lane approach, Stop Here For Pedestrians (R1-5 series) signs (see Section 2B.11) shall be used.

GUIDANCE:

Stop lines and Stop Here For Pedestrians signs should not be used in advance of crosswalks that cross an approach to or departure from a roundabout.

SUPPORT:

When drivers yield or stop too close to crosswalks that cross uncontrolled multi-lane approaches, they place pedestrians at risk by blocking other drivers' views of pedestrians and by blocking pedestrians' views of vehicles approaching in the other lanes.

3B.17 Do Not Block Intersection Markings

OPTION:

Do Not Block Intersection markings may be used to mark the edges of an intersection area that is in close proximity to a signalized intersection, railroad crossing, or other nearby traffic control that might cause vehicles to stop within the intersection and impede other traffic entering the intersection. If authorized by law, Do Not Block Intersection markings with appropriate signs may also be used at other locations.

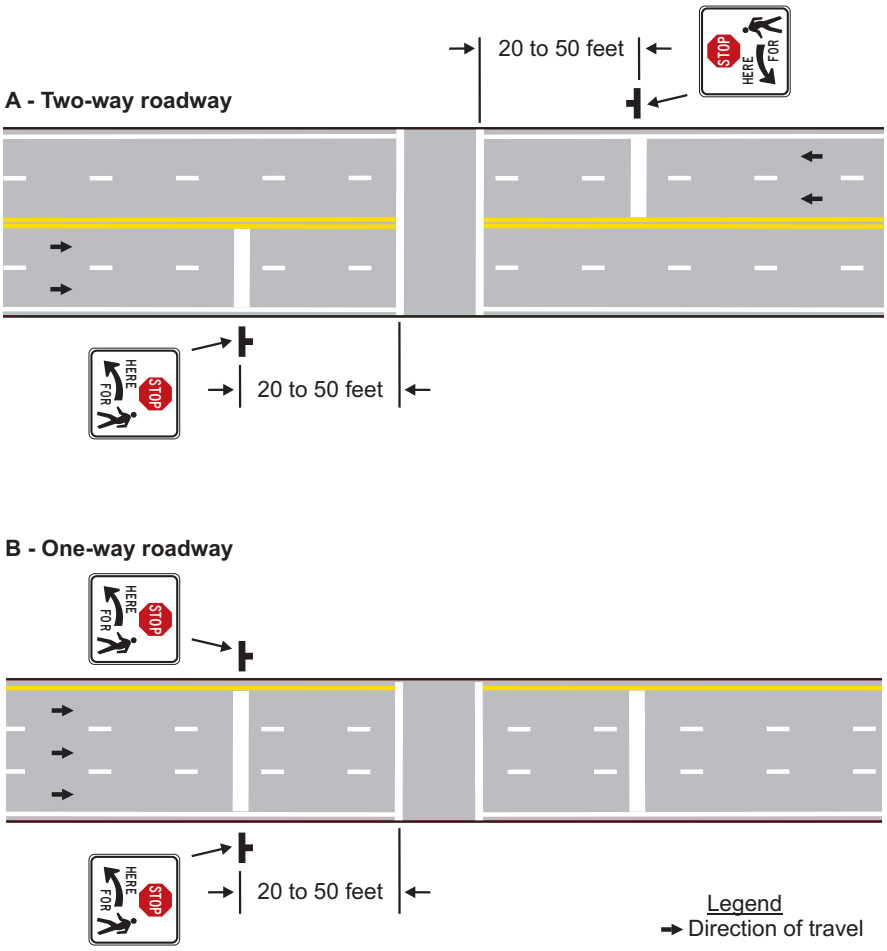


Figure 3B-17 Examples of Stop Lines at Unsignalized Midblock Crosswalks

STANDARD:

If used, Do Not Block Intersection markings (see Figure 3B-18) shall consist of one of the following alternatives:

A. Wide solid white lines that outline the intersection area that vehicles must not block;
B. Wide solid white lines that outline the intersection area that vehicles must not block and a white word message such as DO NOT BLOCK or KEEP CLEAR;
C. Wide solid white lines that outline the intersection area that vehicles must not block and white cross-hatching within the intersection area; or
D. A white word message, such as DO NOT BLOCK or KEEP CLEAR, within the intersection area that vehicles must not block.

Do Not Block Intersection markings shall be accompanied by one or more Do Not Block Intersection (DRIVEWAY) (CROSSING) (R10-7) signs (see Section 2B.53), one or more Do Not Stop On Tracks (R8-8) signs (see Section 8B.9), or one or more similar signs.

3B.18 Crosswalk Markings

SUPPORT:

Crosswalk markings provide guidance for pedestrians who are crossing roadways by defining and delineating paths on approaches to and within signalized intersections, and on approaches to other intersections where traffic stops.

In conjunction with signs and other measures, crosswalk markings help to alert road users of a designated pedestrian crossing point across roadways at locations that are not controlled by traffic control signals or STOP or YIELD signs.

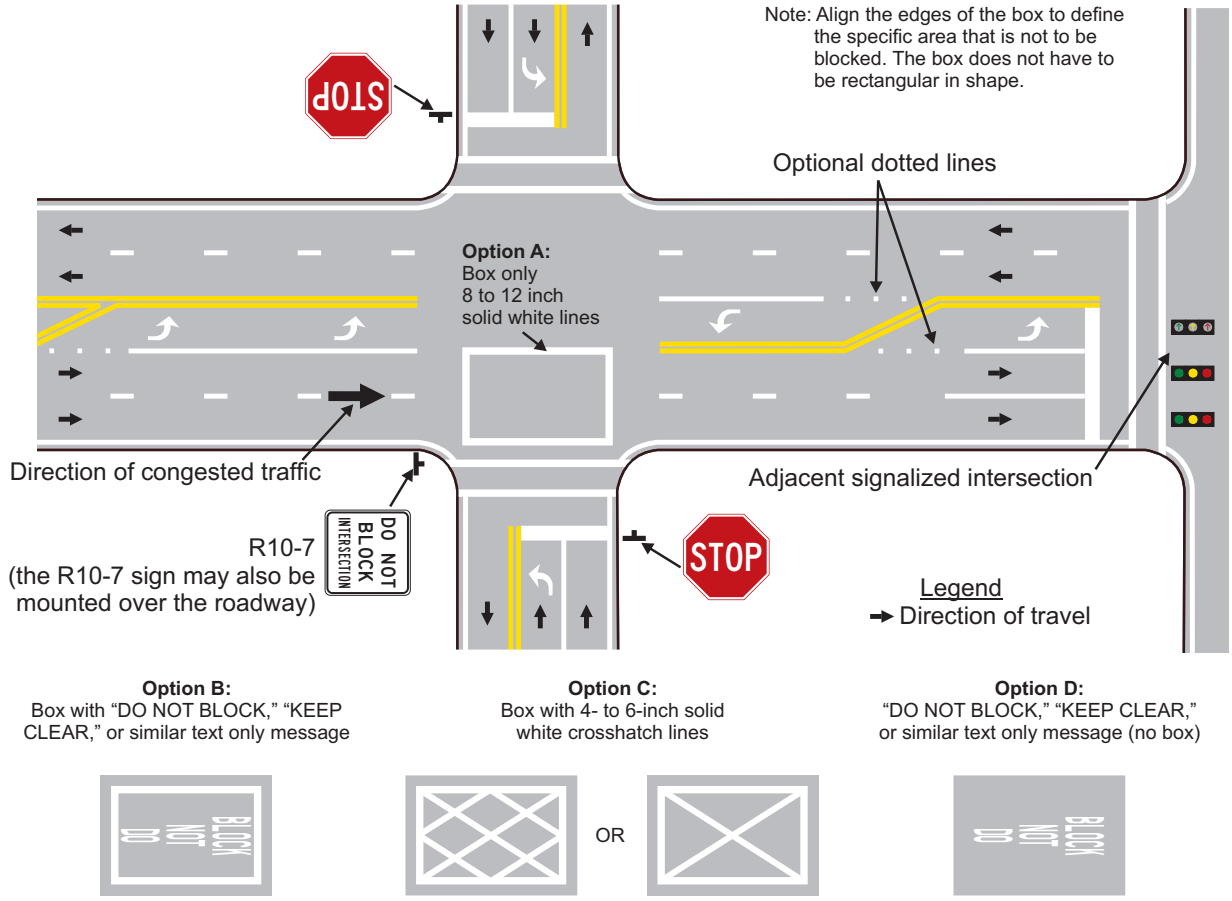


Figure 3B-18 Do Not Block Intersection Markings

At non-intersection locations, crosswalk markings legally establish the crosswalk.

STANDARD:

When crosswalk lines are used, they shall consist of solid white lines that mark the crosswalk. They shall not be less than 6 inches or greater than 24 inches in width.

GUIDANCE:

If transverse lines are used to mark a crosswalk, the gap between the lines should not be less than 6 feet. If diagonal or longitudinal lines are used without transverse lines to mark a crosswalk, the crosswalk should be not less than 6 feet wide.

Crosswalk lines, if used on both sides of the crosswalk, should extend across the full width of pavement to the edge of the intersecting crosswalk to discourage diagonal walking between crosswalks (see Figure 3B-17 and 3B-19).

At locations controlled by traffic control signals or on approaches controlled by STOP or YIELD signs, crosswalk lines should be installed where engineering judgment indicates they are needed to direct pedestrians to the proper crossing path(s).

Crosswalk lines should not be used indiscriminately. An engineering study should be performed before a marked crosswalk is installed at a location away from a traffic control signal or an approach controlled by a STOP or YIELD sign. The engineering study should consider the number of lanes, the presence of a median, the distance from adjacent signalized intersections, the pedestrian volumes

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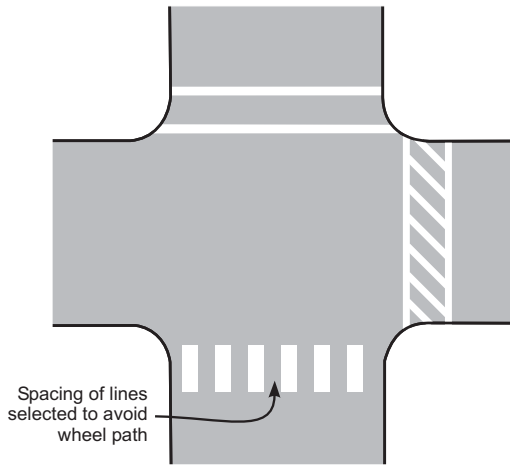

Figure 3B-19 Examples of Crosswalk Markings

and delays, the average daily traffic (ADT), the posted or statutory speed limit or 85th-percentile speed, the geometry of the location, the possible consolidation of multiple crossing points, the availability of street lighting, and other appropriate factors.

New marked crosswalks alone, without other measures designed to reduce traffic speeds, shorten crossing distances, enhance driver awareness of the crossing, and/or provide active warning of pedestrian presence, should not be installed across uncontrolled roadways where the speed limit exceeds 40 mph and either:

A. The roadway has four or more lanes of travel without a raised median or pedestrian refuge island and an ADT of 12,000 vehicles per day or greater; or
B. The roadway has four or more lanes of travel with a raised median or pedestrian refuge island and an ADT of 15,000 vehicles per day or greater.

SUPPORT:

Chapter 4F contains information on Pedestrian Hybrid Beacons. Section 4L.3 contains information regarding Warning Beacons to provide active warning of a pedestrian's presence. Section 4N.2 contains information regarding In-Roadway Warning Lights at crosswalks. Chapter 7D contains information regarding school crossing supervision.

GUIDANCE:

Because non-intersection pedestrian crossings are generally unexpected by the road user, warning signs (see Section 2C.50) should be installed for all marked crosswalks at non-intersection locations and adequate visibility should be provided by parking prohibitions.

SUPPORT:

Section 3B.16 contains information regarding placement of stop line markings near crosswalk markings.

OPTION:

For added visibility, the area of the crosswalk may be marked with white diagonal lines at a 45-degree angle to the line of the crosswalk or with white longitudinal lines parallel to traffic flow as shown in Figure 3B-19.

When diagonal or longitudinal lines are used to mark a crosswalk, the transverse crosswalk lines may be omitted. This type of marking may be used at locations where substantial numbers of pedestrians cross without any other traffic control device, at locations where physical conditions are such that added visibility of the crosswalk is desired, or at places where a pedestrian crosswalk might not be expected.

GUIDANCE:

If used, the diagonal or longitudinal lines should be 12 to 24 inches wide and separated by gaps of 12 to 60 inches. The design of the lines and gaps should avoid the wheel paths if possible, and the gap between the lines should not exceed 2.5 times the width of the diagonal or longitudinal lines.

OPTION:

When an exclusive pedestrian phase that permits diagonal crossing is provided at a traffic control signal, a marking as

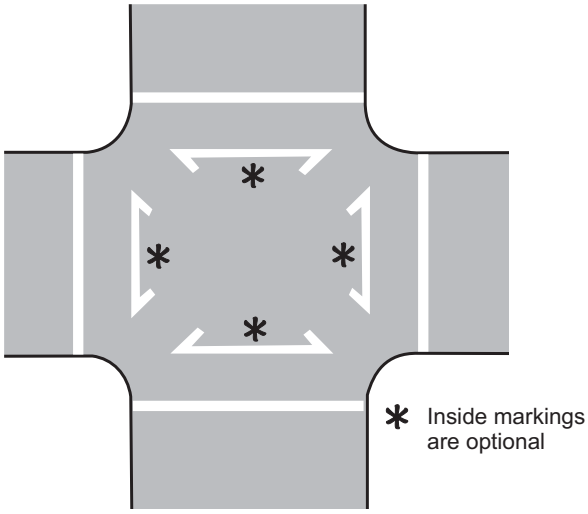

Figure 3B-20 Examples of Crosswalk Markings for an Exclusive Pedestrian Phase That Permits Diagonal Crossing

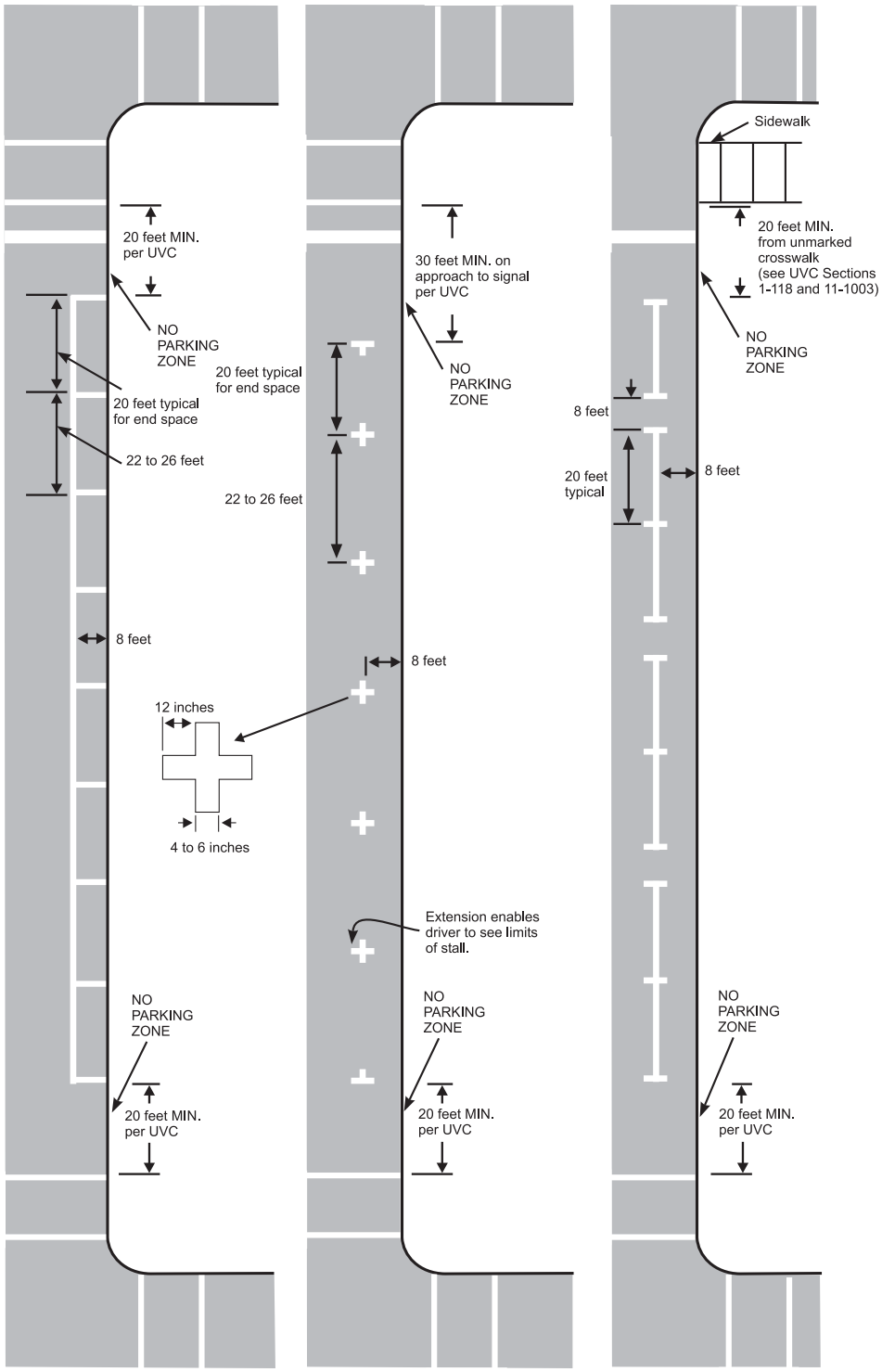

Figure 3B-21 Examples of Parking Space Markings

shown in Figure 3B-20 may be used for the crosswalk.

GUIDANCE:

Crosswalk markings should be located so that the curb ramps are within the extension of the crosswalk markings.

SUPPORT:

Detectable warning surfaces mark boundaries between pedestrian and vehicular ways where there is no raised curb. Detectable warning surfaces are required by 49 CFR, Part 37 and by the Americans with Disabilities Act (ADA) where curb ramps are constructed at the junction of sidewalks and the roadway, for marked and unmarked crosswalks. Detectable warning surfaces contrast visually with adjacent walking surfaces, either light-on- dark, or dark-on-light. The "Americans with Disabilities Act Accessibility Guidelines for Buildings and Facilities (ADAAG)" (see Section 1A.11) contains specifications for design and placement of detectable warning surfaces.

3B.19 Parking Space Markings

SUPPORT:

Marking of parking space boundaries encourages more orderly and efficient use of parking spaces where parking turnover is substantial. Parking space markings tend to prevent encroachment into fire hydrant zones, bus stops, loading zones, approaches to intersections, curb ramps, and clearance spaces for islands and other zones where parking is restricted. Examples of parking space markings are shown in Figure 3B-21.

STANDARD:

Parking space markings shall be white.

OPTION:

Blue lines may supplement white parking space markings of each parking space designated for use only by persons with disabilities.

SUPPORT:

Additional parking space markings for the purpose of designating spaces for use only by persons with disabilities are discussed in Section 3B.20 and illustrated in Figure 3B-22. The design and layout of accessible parking spaces for persons with disabilities is provided in the "Americans with Disabilities Act Accessibility Guidelines (ADAAG)" (see Section 1A.11).

3B.20 Pavement Word, Symbol, and Arrow Markings

SUPPORT:

Word, symbol, and arrow markings on the pavement are used for the purpose of guiding, warning, or regulating traffic. These pavement markings can be helpful to road users in some locations by supplementing signs and providing additional emphasis for important regulatory, warning, or guidance messages, because the markings do not require diversion of the road user's attention from the

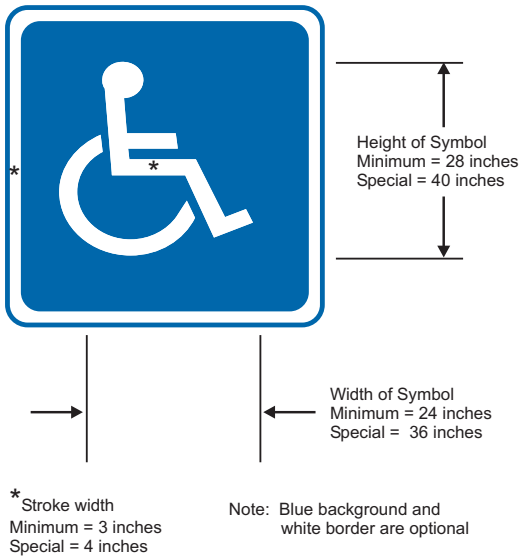

Figure 3B-22 International Symbol of Accessibility Parking Space Marking

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9. SPECIFICATIONS AND TABULATION OF QUANTITIES

9.1 GENERAL

Chapter 9 will review the MnDOT Specifications and how they relate traffic signal projects. This Chapter will also review tabulation of quantities for traffic control signal systems.

9.2 SPECIFICATIONS

9.2.1 Traffic Signals MnDOT 2014 Standard Specification for Construction Book (Spec Book)

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.

The 2014 Spec Book includes both metric and non-metric units of measure conversions. The 2014 Spec book also includes numerous modifications to the 2005 Spec Book.

9.2.1.1 Format of the "Spec Book"

The Spec Book is made of three divisions:

Division I - General Requirements and Covenants

Division II - Construction Details

Division III - Materials

A section of Division I that all designers need to be particularly aware of is as follows:

MnDOT 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."

9.2.1.2 Format of MnDOT 2565 (Traffic Signals)

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 either a traffic control signal system or an electric lighting system. MnDOT 2545 (Electric lighting systems) does cross reference a number of specifications within MnDOT 2565.

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, traffic control signal system projects do use other "individual" pay items. These pay items are written as part of the Special Provisions. See the Special Provisions section of this Chapter for some examples of the pay items used for traffic control signal system projects.

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.

Other National and Local Standards

There are other national and local standards which are applicable to signal plans and specifications. The following are some of the standards specified in the Spec Book:

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.

9.2.2 MnDOT Contract Proposal

9.2.2.1 Contents

Each MnDOT project has a proposal. The proposal contains items such as:

- Addendums
- Notices to Bidders
- Appendices
- Special Provisions (by division, for example: Division A, Divisions S, Division SS, Division SL, Division ST, etc.)
- Attachments
- Contract Schedule (Bid Prices)

9.2.2.2 Special Provisions

Special Provisions are defined as:

"Additions and revisions to the Standard and Supplemental Specifications covering conditions peculiar to an individual project"

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.

Division SS covers traffic control signal systems. Special Provisions may be formatted into more than one SS section. For example:

<u>Traffic control signal system (Division SS)</u>

- SS-1 Qualifications of Workers
- SS-2 Traffic Control Signals
- SS-3 Emergency Vehicle Preemption (EVP) System
- SS-4 Traffic Control Interconnection

A typical set of Special Provisions for a traffic control signal system are formatted similar to the Spec Book; however, the actual format of the Special Provisions may vary somewhat when compared to the Spec Book format. The following is how the Special Provisions for traffic control signal systems are formatted:

- Opening Descriptive Paragraph
- General Section
- Materials
- Construction Requirements
- Measurement and Payment

Special Provisions may also include detail drawings that are pertinent to the specific project.

All traffic control signal system Special Provisions that are part of the MnDOT projects or have State Aid money involved will have a SS-1 "Qualification of Workers" specification.

The following is a closer look at a typical set of Special Provisions for a traffic control 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 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.

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 traffic control 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 traffic control signal system will be measured and paid for. The pay item(s) 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 traffic control 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).

See the Appendix for a sample of a typical set of MnDOT Special Provisions and the typical specifications that are included in the various sections.

9.2.2.3 Attachments

MnDOT traffic control signal system projects that include pavement markings as an incidental item to the signals system will have the pavement marking specifications attached in the "Attachment Section" of the overall project Contract.

9.2.2.4 Addendum

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". This addendum is then

sent out to Contractors, suppliers, etc. that have purchased the Contract documents for the specific project. This addendum is sent out with enough lead time to allow bidders the opportunity to consider the addendum in preparing their bid. The *addendum will be located in the front portion of the MnDOT project proposal.*

9.2.2.5 Supplemental Agreements

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.

9.3 TABULATION OF QUANTITIES

In order to generate a cost estimate for the traffic control signal system, the designer needs to submit a "Tabulation of Quantities" for all traffic control signal system component parts. The list (shown below) is turned in to the MnDOT Estimating Unit at or before the time of final Plan turn-in.

Item Number	Description	Unit	Quantity
2565.511/00010	TRAFFIC CONTROL SIGNAL SYSTEM	SIG SYS	
2565.511/00011	TRAFFIC CONTROL SIGNAL SYSTEM A	SIG SYS	
2565.511/00012	TRAFFIC CONTROL SIGNAL SYSTEM B	SIG SYS	
2565.511/00013	TRAFFIC CONTROL SIGNAL SYSTEM C	SIG SYS	
2565.511/00014	TRAFFIC CONTROL SIGNAL SYSTEM D	SIG SYS	
2565.601/00009	PAINT SIGNAL SYSTEM	LUMP SUM	
2565.601/00025	TRAFFIC CONTROL SIGNALS	LUMP SUM	
2565.601/00031	STATE FURNISHED MATERIAL	LUMP SUM	
2565.601/00032	CITY FURNISHED MATERIAL	LUMP SUM	
2565.601/00033	COUNTY FURNISHED MATERIAL	LUMP SUM	
2565.601/00040	EMERGENCY VEHICLE PREEMPTION SYSTEM	LUMP SUM	
2565.601/00041	EMERGENCY VEHICLE PREEMPTION SYS A	LUMP SUM	
2565.601/00042	EMERGENCY VEHICLE PREEMPTION SYS B	LUMP SUM	
2565.601/00043	EMERGENCY VEHICLE PREEMPTION SYS C	LUMP SUM	
2565.601/00044	EMERGENCY VEHICLE PREEMPTION SYS D	LUMP SUM	
2565.601/00110	TRAFFIC CONTROL INTERCONNECTION	LUMP SUM	
2565.601/00111	TRAFFIC CONTROL INTERCONNECTION A	LUMP SUM	
2565.601/00112	TRAFFIC CONTROL INTERCONNECTION B	LUMP SUM	
2565.601/00150	INSTALL FLASHER SYSTEM	LUMP SUM	
2565.601/00200	FURNISH TRAFFIC CONTROL SIG SYS MATERIAL	LUMP SUM	
2565.601/00500	REVISE EMERGENCY VEHICLE PREEMPT SYSTEM	LUMP SUM	
2565.601/00600	SIGNAL OPTIMIZATION & TIMING	LUMP SUM	
2565.602/00003	HANDHOLE	EACH	

Item Number	Description	Unit	Quantity
2565.602/00004	SPECIAL HANDHOLE	EACH	
2565.602/00006	CONCRETE HANDHOLE - TYPE HD	EACH	
2565.602/00008	HANDHOLE DESIGN MPLS	EACH	
2565.602/00011	EQUIPMENT PAD	EACH	
2565.602/00012	NON-METALLIC JUNCTION BOX	EACH	
2565.602/00014	PEDESTAL FOUNDATION	EACH	
2565.602/00015	METAL JUNCTION BOX	EACH	
2565.602/00017	FIBEROPTIC CABINET FOUNDATION	EACH	
2565.602/00018	INSTALL SERVICE EQUIPMENT	EACH	
2565.602/00019	REVISE SERVICE EQUIPMENT	EACH	
2565.602/00020	SERVICE EQUIPMENT	EACH	
2565.602/00029	SPLICE CABINET FOUNDATION	EACH	
2565.602/00031	ADJUST HANDHOLE	EACH	
2565.602/00032	INSTALL HANDHOLE	EACH	
2565.602/00039	SIGNAL SERVICE CABINET TYPE SSB	EACH	
2565.602/00040	REVISE SIGNAL SERVICE CABINET	EACH	
2565.602/00043	INSTALL CABINET	EACH	
2565.602/00049	MODIFY FOUNDATION	EACH	
2565.602/00050	PEDESTAL POLE & BASE	EACH	
2565.602/00051	INSTALL PEDESTAL POLE & BASE	EACH	
2565.602/00054	INSTALL SIGN PANEL	EACH	
2565.602/00056	MAST ARM POLE & FOUNDATION	EACH	
2565.602/00060	DOWN GUY GUARD & ANCHOR	EACH	
2565.602/00070	LUMINAIRE & MAST ARM	EACH	
2565.602/00090	EQUIPMENT PAD	EACH	
2565.602/00094	SPLICE CABINET	EACH	
2565.602/00103	LOAD CENTER (PAD MOUNTED)	EACH	
2565.602/00104	LOAD CENTER (WOOD POLE MOUNTED)	EACH	
2565.602/00120	INSTALL WOOD POLE	EACH	
2565.602/00130	30' WOOD POLE	EACH	
2565.602/00140	40' WOOD POLE	EACH	
2565.602/00145	45' WOOD POLE	EACH	
2565.602/00155	55' WOOD POLE	EACH	
2565.602/00200	PAINT FLASHER	EACH	
2565.602/00201	PAINT A.T.R. CABINET	EACH	
2565.602/00205	PAINT SIGNAL SYSTEM	EACH	
2565.602/00250	SIGNAL AHEAD FLASHER	EACH	
2565.602/00270	FURNISH APS CONTROL UNIT	EACH	
2565.602/00290	PEDESTRIAN SIGNAL INDICATION	EACH	
2565.602/00295	PEDESTRIAN SIGNAL HEAD	EACH	

Item Number	Description	Unit	Quantity
2565.602/00296	APS PEDESTRIAN PUSH BUTTON & SIGN	EACH	
2565.602/00298	APS PEDESTRIAN PUSH BUTTON STATION	EACH	
2565.602/00299	APS PED PUSH BUTTON STATION FOUNDATION	EACH	
2565.602/00301	APS PEDESTRIAN PUSH BUTTON	EACH	
2565.602/00305	APS RELOCATE PEDESTRIAN PUSH BUTTON	EACH	
2565.602/00308	INSTALL APS PED PUSH BUTTON STATION	EACH	
2565.602/00309	INSTALL APS PED PUSH BUTTON & SIGN	EACH	
2565.602/00498	ONE WAY EVP INDICATION	EACH	
2565.602/00499	ONE WAY EVP DETECTOR	EACH	
2565.602/00500	ONE WAY EVP DETECTOR & INDICATION	EACH	
2565.602/00501	TWO WAY EVP DETECTOR & INDICATION	EACH	
2565.602/00550	SERVICE EQUIPMENT (POLE MOUNTED)	EACH	
2565.602/00551	SERVICE EQUIPMENT (PAD MOUNTED)	EACH	
2565.602/00780	TRANSFORMER & SERVICE EQUIPMENT	EACH	
2565.602/00799	INSTALL CABINET & ATR EQUIPMENT	EACH	
2565.602/00900	RED LED INDICATION	EACH	
2565.602/00910	RED ARROW LED INDICATION	EACH	
2565.602/00920	GREEN LED INDICATION	EACH	
2565.602/00930	GREEN ARROW LED INDICATION	EACH	
2565.602/00940	YELLOW LED INDICATION	EACH	
2565.602/00960	SIGNAL INDICATION RELAMP	EACH	
2565.602/00970	TERMINAL BLOCK	EACH	
2565.602/40001	SPLICE LOOP DETECTOR	EACH	
2565.602/40005	TEMPORARY LOOP DETECTOR	EACH	
2565.602/50000	RIGID PVC LOOP DETECTOR	EACH	
2565.602/51717	RIGID PVC LOOP DETECTOR 6'X6'	EACH	
2565.602/51724	RIGID PVC LOOP DETECTOR 6'X8'	EACH	
2565.602/51730	RIGID PVC LOOP DETECTOR 6'X10'	EACH	
2565.602/51734	RIGID PVC LOOP DETECTOR 6'X11'	EACH	
2565.602/51736	RIGID PVC LOOP DETECTOR 6'X12'	EACH	
2565.602/51746	RIGID PVC LOOP DETECTOR 6'X15'	EACH	
2565.602/51762	RIGID PVC LOOP DETECTOR 6'X20'	EACH	
2565.602/61717	SAW CUT LOOP DETECTOR 6' X 6'	EACH	
2565.602/61730	SAW CUT LOOP DETECTOR 6' X 10'	EACH	
2565.603/00010	INSTALL CABLES & CONDUCTORS	LIN FT	
2565.603/00020	FIBER OPTIC INTERCONNECT	LIN FT	
2565.603/00030	TUBE LIGHTING	LIN FT	
2565.603/00110	1.0" NON-METALLIC CONDUIT	LIN FT	
2565.603/00113	1.25" NON-METALLIC CONDUIT	LIN FT	
2565.603/00115	1.5" NON-METALLIC CONDUIT	LIN FT	

Item Number	Description	Unit	Quantity
2565.603/00120	2" NON-METALLIC CONDUIT	LIN FT	
2565.603/00122	2" NON-METALLIC CONDUIT BRIDGE MOUNTED	LIN FT	
2565.603/00123	2" NON-METALLIC COND (DIRECTIONAL BORE)	LIN FT	
2565.603/00124	2" NON METALLIC CONDUIT INTERCONNECT	LIN FT	
2565.603/00125	2.5" NON-METALLIC CONDUIT	LIN FT	
2565.603/00130	3" NON-METALLIC CONDUIT	LIN FT	
2565.603/00134	3" NON METALLIC CONDUIT INTERCONNECT	LIN FT	
2565.603/00140	4" NON-METALLIC CONDUIT	LIN FT	
2565.603/00143	4" NON-METALLIC COND (DIRECTIONAL BORE)	LIN FT	
2565.603/00150	5" NON-METALLIC CONDUIT	LIN FT	
2565.603/00160	6" NON-METALLIC CONDUIT	LIN FT	
2565.603/00163	6" NON-METALLIC COND (DIRECTIONAL BORE)	LIN FT	
2565.603/02010	1" RIGID STEEL CONDUIT	LIN FT	
2565.603/02014	1.25" RIGID STEEL CONDUIT	LIN FT	
2565.603/02016	1.25" RIGID STEEL CONDUIT INTERCONNECT	LIN FT	
2565.603/02017	1.5" RIGID STEEL CONDUIT	LIN FT	
2565.603/02020	2" RIGID STEEL CONDUIT	LIN FT	
2565.603/02024	2" RIGID STEEL CONDUIT INTERCONNECT	LIN FT	
2565.603/02025	2.5" RIGID STEEL CONDUIT	LIN FT	
2565.603/02030	3" RIGID STEEL CONDUIT	LIN FT	
2565.603/02032	3" RIGID STEEL CONDUIT PUSHED	LIN FT	
2565.603/02034	3" RIGID STEEL CONDUIT INTERCONNECT	LIN FT	
2565.603/02040	4" RIGID STEEL CONDUIT	LIN FT	
2565.603/05100	1/C#1/0	LIN FT	
2565.603/05101	1/C#1/0 BARE GROUND	LIN FT	
2565.603/05102	1/C#2	LIN FT	
2565.603/05103	1/C#2/0	LIN FT	
2565.603/05104	1/C#2 BARE GROUND	LIN FT	
2565.603/05120	1/C#4	LIN FT	
2565.603/05121	1/C#4/0	LIN FT	
2565.603/05123	1/C#4 BARE GROUND	LIN FT	
2565.603/05130	1/C#6	LIN FT	
2565.603/05131	1/C#6 BARE GROUND	LIN FT	
2565.603/05141	1/C#8 BARE GROUND	LIN FT	
2565.603/05150	1/C#10	LIN FT	
2565.603/05172	1/C#14 INTERCONNECT	LIN FT	
2565.603/05220	2/C#12 TYPE UF	LIN FT	
2565.603/05221	INSTALL 2/C#12	LIN FT	
2565.603/05270	2/C#14 LOOP LEAD-IN	LIN FT	
2565.603/05320	3/C#4	LIN FT	

Item Number	Description	Unit	Quantity
2565.603/05370	3/C#14	LIN FT	
2565.603/05390	3/C#20	LIN FT	
2565.603/05391	INSTALL 3/C#20	LIN FT	
2565.603/05407	4/C#14	LIN FT	
2565.603/05620	6/C FIBER OPTIC CABLE - INTERCONNECT	LIN FT	
2565.603/05707	7/C#14	LIN FT	
2565.603/05905	6 PR #19	LIN FT	
2565.603/05909	6 PR #19 INTERCONNECT	LIN FT	
2565.603/05910	INSTALL 6 PR #19 INTERCONNECT	LIN FT	
2565.603/05913	12/PR #19	LIN FT	
2565.603/05914	12 PR #19 INTERCONNECT	LIN FT	
2565.603/06000	25 PR #19	LIN FT	
2565.603/06001	25 PR #19 DIRECT BURIAL	LIN FT	
2565.603/06002	INSTALL 25 PR #19	LIN FT	
2565.603/06010	2/C TELEPHONE DROP WIRE	LIN FT	
2565.603/06312	FIBER OPTIC TRUNK CABLE 12MM	LIN FT	
2565.603/06336	FIBEROPTIC TRUNK CABLE 12MM-36SM	LIN FT	
2565.603/06412	FIBER OPTIC TRUNK CABLE 12SM	LIN FT	
2565.603/06500	VIDEO CABLE RG11	LIN FT	
2565.603/06501	COAXIAL CABLE	LIN FT	
2565.603/06502	COAXIAL ARMORED CABLE	LIN FT	
2565.603/06503	RF TRANSMISSION CABLE	LIN FT	
2565.603/06520	SENSOR CABLE	LIN FT	
2565.603/06619	TELEPHONE CABLE 6 PR NO 19	LIN FT	
2565.603/06716	7/16" SPAN WIRE	LIN FT	
2565.603/08000	27 PR/NO 22 VAR MESSAGE SIGN CABLE	LIN FT	
2565.616/00001	FLASHING BEACON SYSTEM	SYSTEM	
2565.616/00003	INSTALL FLASHING BEACON SYSTEM	SYSTEM	
2565.616/00004	TEMPORARY FLASHING BEACON SYSTEM	SYSTEM	
2565.616/00005	FLASHING BEACON SYSTEM A	SYSTEM	
2565.616/00020	TEMPORARY BRIDGE SIGNAL SYSTEM	SYSTEM	
2565.616/00021	TEMPORARY BRIDGE SIGNAL SYSTEM A	SYSTEM	
2565.616/00040	AUTOMATIC TRAFFIC RECORDER SYSTEM	SYSTEM	
2565.616/00041	REVISE AUTOMATIC TRAFFIC RECORDER	SYSTEM	
2565.616/00047	VIDEO DETECTOR SYSTEM	SYSTEM	
2565.616/00060	PEDESTRIAN CROSSWALK FLASHER SYSTEM	SYSTEM	
2565.616/00080	REVISE FLASHER SYSTEM	SYSTEM	
2565.616/00100	REVISE SIGNAL SYSTEM	SYSTEM	
2565.616/00101	REVISE SIGNAL SYSTEM A	SYSTEM	
2565.616/00102	REVISE SIGNAL SYSTEM B	SYSTEM	

Item Number	Description	Unit	Quantity
2565.616/00103	REVISE SIGNAL SYSTEM C	SYSTEM	
2565.616/00104	REVISE SIGNAL SYSTEM D	SYSTEM	
2565.616/00105	REVISE SIGNAL SYSTEM E	SYSTEM	
2565.616/00106	REVISE SIGNAL SYSTEM F	SYSTEM	
2565.616/00107	REVISE SIGNAL SYSTEM G	SYSTEM	
2565.616/00108	REVISE SIGNAL SYSTEM H	SYSTEM	
2565.616/00109	REVISE SIGNAL SYSTEM I	SYSTEM	
2565.616/00110	REVISE SIGNAL SYSTEM J	SYSTEM	
2565.616/00111	REVISE SIGNAL SYSTEM K	SYSTEM	
2565.616/00112	REVISE SIGNAL SYSTEM L	SYSTEM	
2565.616/00113	REVISE SIGNAL SYSTEM M	SYSTEM	
2565.616/00114	REVISE SIGNAL SYSTEM N	SYSTEM	
2565.616/00115	REVISE SIGNAL SYSTEM O	SYSTEM	
2565.616/00200	REVISE TEMPORARY SIGNAL SYSTEM	SYSTEM	
2565.616/00201	REVISE TEMPORARY SIGNAL SYSTEM A	SYSTEM	
2565.616/00202	REVISE TEMPORARY SIGNAL SYSTEM B	SYSTEM	
2565.616/00300	TEMPORARY SIGNAL SYSTEM	SYSTEM	
2565.616/00301	TEMPORARY SIGNAL SYSTEM A	SYSTEM	
2565.616/00302	TEMPORARY SIGNAL SYSTEM B	SYSTEM	
2565.616/00303	TEMPORARY SIGNAL SYSTEM C	SYSTEM	

10. ADVANCED WARNING FLASHERS (AWF)

The information following this page is a handout taken from the Signal Timing and Coordination Manual and the Minnesota Manual on Uniform Traffic Control Devices. The most current version of these documents can be found at:

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

Note: It is recommended that you review all original reference material.

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.

HANDOUT

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

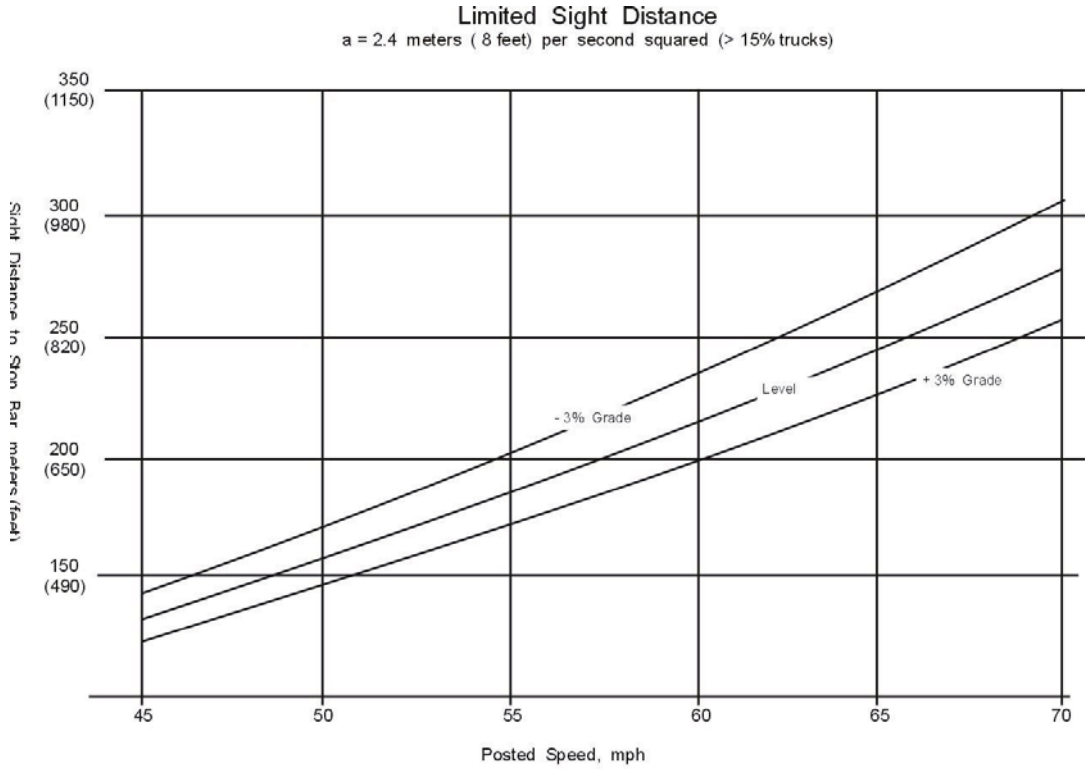
D = AWF Placement, meters

v = posted speeds, mph

$$F = \frac{0.68D}{v} - 1.5$$

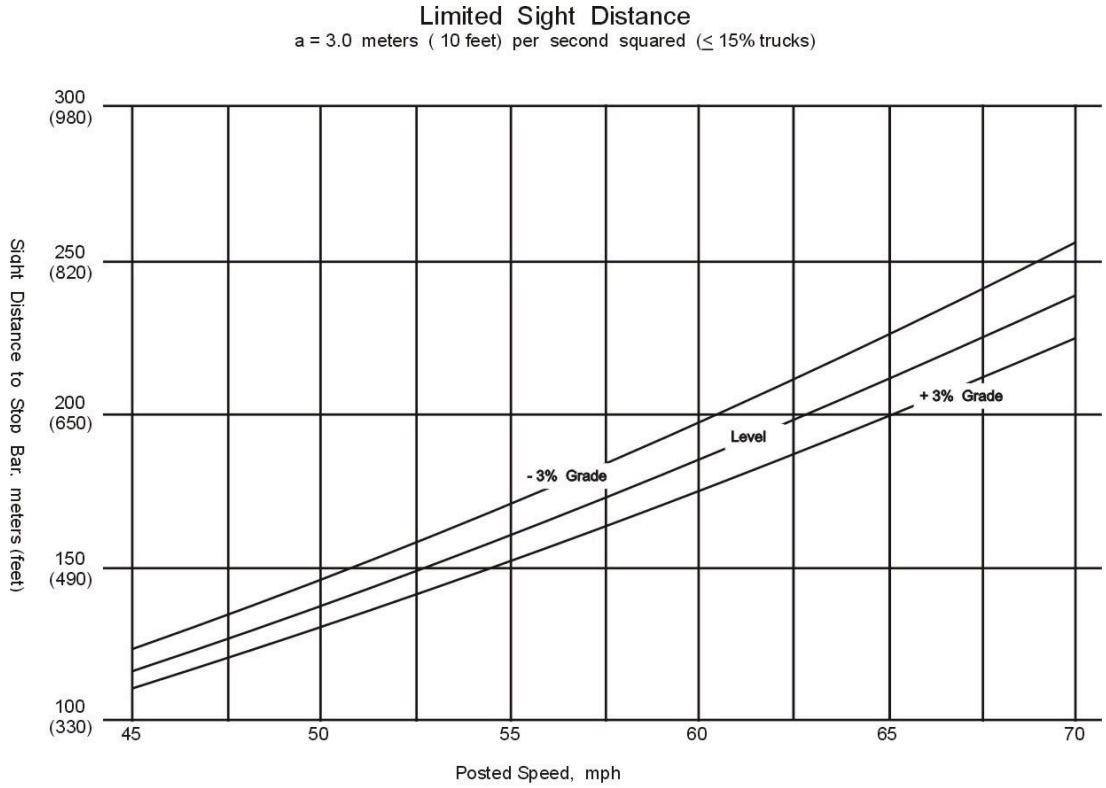
4. **Detector Placement** - The detection of the intersection shall be determined without regard to the AWF.

Exhibit 4-12 AWF Limited Sight Distance (> 15% Trucks)



A sight distance falling below the lines for the given speed and grade indicates the possible need for an AWF.

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)

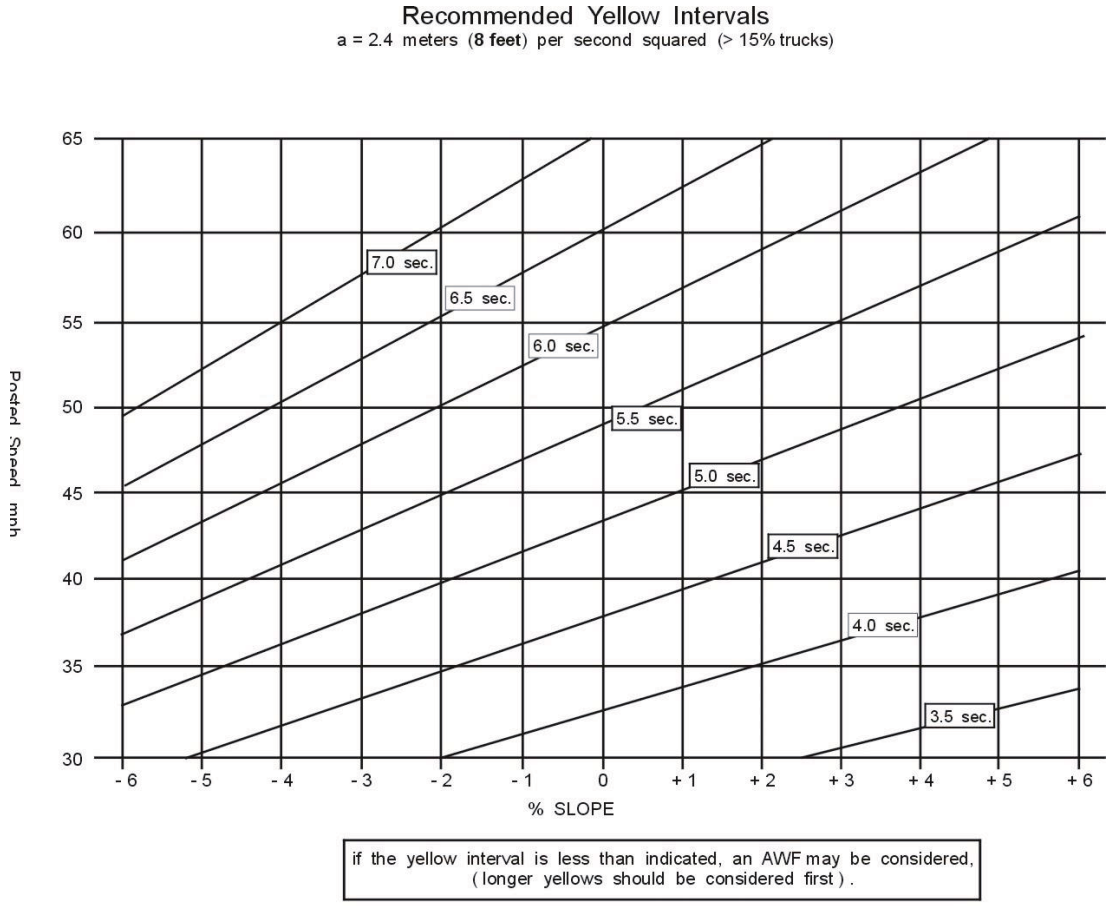
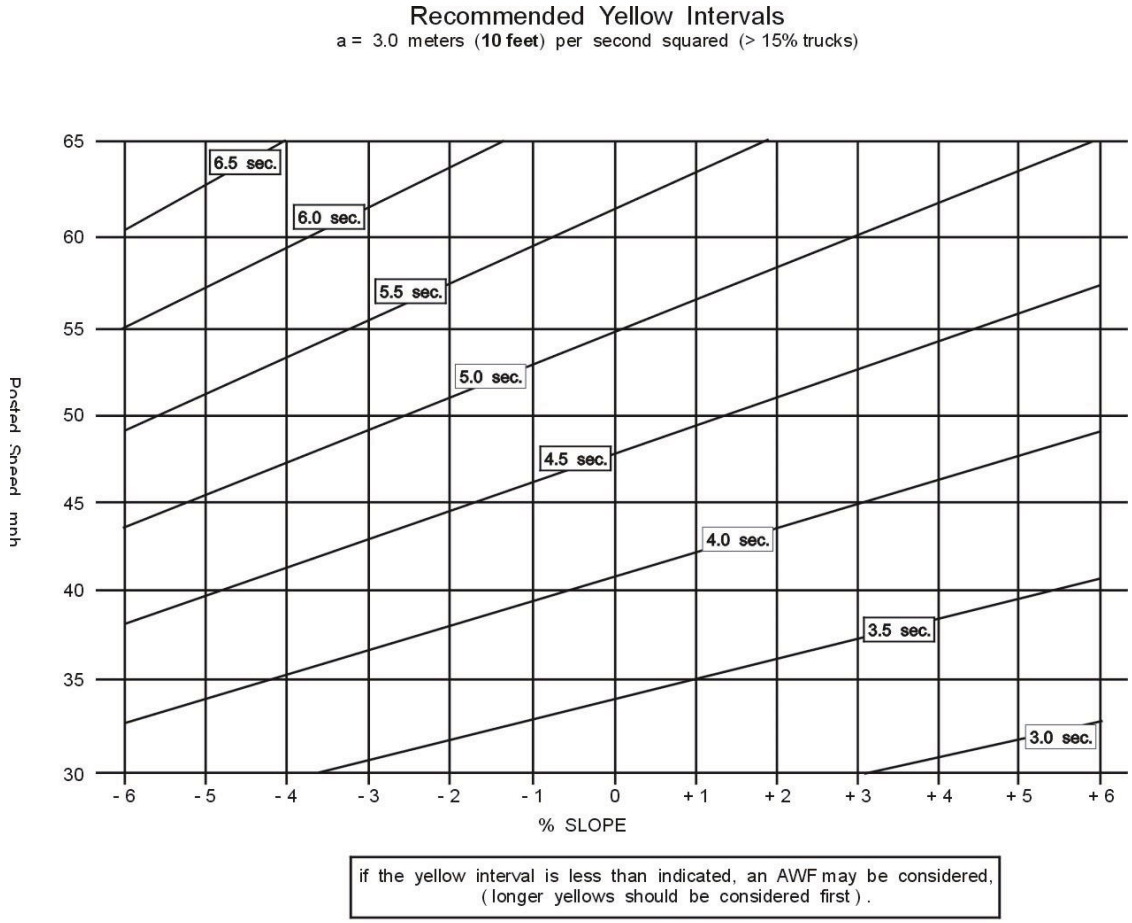


Exhibit 4-15 AWF Recommended Yellow Intervals (≤ 15% Trucks)



See **MN MUTCD** for the Installation and Operation of Advanced Warning Flashers.

11. PREEMPTION

The information following this page is a handout taken from the Signal Timing and Coordination Manual and the Minnesota Manual on Uniform Traffic Control Devices. The most current version of these documents can be found at:

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

Note: It is recommended that you review all original reference material.

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.

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

Version 11/21/2007

Mn/DOT ANNUAL TRAFFIC SIGNAL AND RAILROAD PREEMPTION INSPECTION FORM

1. LOCATION DATA

CITY:	COUNTY:	OPERATING AGENCY:
HIGHWAY INTERSECTION:		Mn/DOT DISTRICT:
RAILROAD COMPANY:	RAILROAD INVENTORY NUMBER:	

2. RAILROAD PREEMPTION PHASING SEQUENCE

CRITICAL PHASES		TRACK CLEARANCE PHASE(S)	PREEMPT HOLD OR CYCLE PHASES
Vehicle:	**Pedestrian:**		

3. RAILROAD DATA / 4. TRAFFIC SIGNAL HARDWARE DATA

RR ACTIVE WARNING DEVICES: **Flashers, no gates.**	GATE-DOWN LOGIC INSTALLED?	CONTROLLER MODEL:	OPERATION (pretimed/actuated):
DETECTOR MODEL/TYPE:		EVP PRESENT?	CONFIRMATION LIGHTS PRESENT?
MAXIMUM TRAIN SPEED (MPH):	NUMBER OF TRACKS:	ROADWAY CHANGES?	
NUMBER OF TRAINS PER DAY (and any helpful additional information):		WORKING MANUAL PREEMPTION SWITCH IN CABINET?	
DATE OF MOST CURRENT RAILROAD PLANS (in bungalow):		LOOPS UPSTREAM OF TRACKS (if vehicles must stop before tracks)?	
APPROACH AND ISLAND LENGTHS (FEET): Island: Approaches:		TYPE OF BACKUP POWER:	

5. RAILROAD EQUIPMENT PROGRAMMED TIMINGS

Equipment Response (Buffer) Time:		sec.
Extra Warning Time (overspeed tolerance, wide/angled crossings):		sec.
Minimum Warning Time:	20	sec.
Advance Preemption Time:		sec.
Total Warning Time (excludes equipment response/buffer time):	20	sec.

6. NOTES

7. FIELD TESTING AND INSPECTION

Weather Conditions:

Test #	1	2	3	4
Train's Direction of Travel				
	Cumulative Time (sec)			
Preempt call received at				
Railroad flasher activated at				
Gate descent started at	no gates	no gates	no gates	no gates
Gate descent completed at	no gates	no gates	no gates	no gates
End of track clearance green (start of track clearance yellow) at				
Train arrived at				
Measured Total Warning Time:				
Railroad equipment and lamps functioned:				
Track clearance and preempt hold/cycle phases operated as expected:				

8. REVIEW TEAM (INCLUDING TELEPHONE NUMBERS)

MAXIMUM WARNING TIME NEEDED BY TRAFFIC SIGNAL: **23.2 sec**

DOES MEASURED WARNING TIME MEET OR EXCEED MAXIMUM WARNING TIME NEEDED BY TRAFFIC SIGNAL?

HIGHWAY		INSPECTION DATE:
RAILROAD		

9. OTHER INFORMATION/NOTES

The information following this page is a memo regarding Standard Design/Operation Practice for MnDOT Signals with Railroad Preemption. It is important to work with the contact shown on page 3 of the memo if you have rail preemption involved in your project. The designer, operator and/or project manager is required to update the railroad preemption form to find the maximum preemption time. The most current version of these documents can be found at:

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

Note: It is recommended that you review all original reference material.

Minnesota Department of Transportation

Memo

Office of Traffic, Security & Operations
Mail Stop 725
1500 County Road B2
Roseville, MN 55113

Office Tel: 651-582-1282
Fax: 651-634-5445

August 3, 2006

From: Sue Zarling
Traffic Electrical Systems Engineer
Office of Traffic, Security and Operations (OTSO)

To: District Traffic Engineers
MN/DOT OFCVO – Project Managers
Minnesota Private Railroad Companies

Subject: Standard Design/Operation Practice for Mn/DOT Signals with Railroad Preemption

Due to the expiration of Technical Memorandum # 00-05-T-01, this memo of understanding will guide the installation of rail road preemption until a new technical memorandum is published.

With direction from Mn/DOT's TEO Signal Committee and Mn/DOT's Office of Freight and Commercial Vehicle Operations (OFCVO), OTSO has defined the design and operation criteria for new traffic signals where railroad preemption is required. This criteria should also be considered when installing railroad preemption at an existing traffic signal. The following hardware should be provided:

- Interconnect from the signal cabinet to the railroad bungalow should be a 12/c #14 cable
- The railroad circuit shall be a double break interconnect circuit with supervision and gate down logic (gate horizontal control).

The following scenario is for a gated roadway approach to a traffic signal:
The traffic controller will run two operational preemption sequences. The first preemption sequence will provide the advanced preemption time. The second preemption sequence will begin once the traffic controller receives the gate down call from the railroad bungalow equipment. A "double break interconnect circuit with supervisor and gate down logic" detail is included within this memo. Crossings that operate simultaneous preemption will also require gate down logic.

Mn/DOTs updated railroad preemption form will be utilized to find the maximum preemption time. This form and instructions can be found at http://www.dot.state.mn.us/trafficeng/standards/signalworksheets.html Once complete, the form will be forwarded to the appropriate Mn/DOT OFCVO Project Manager (see attached map) for processing with the private railroad company. The railroad company will review the maximum preemption time, determining the required train detection distances to accommodate the maximum preemption time. The railroad company may recommend shortening the detector distance if the existing maximum preemption time dictates detection location may be cost prohibited. At times, a

moderate adjustment in the location of the rail detection can have a substantial cost savings. When this happens, a consensus between the railroad company, Mn/DOT OFCVO and the District Signal Section will determine the location of the railroad detection.

When railroad preemption is required at a signalized crossing, eight phase protected turn phasing should be considered for the traffic signal. For signals with no left turn phase on the track clearance phase, an additional green left turn arrow should be designed into the appropriate (4 section red, yellow, green, green arrow) overhead indication. This green arrow will only be used during a rail road preemption sequence.

The following is one of the more notable controller operations, with a protected/permitted track clearance phase, that shall be implemented. Others will be discussed in a tech memo to be written at a later date. If the railroad clearance phase of the traffic controller and its concurrent phase are green (best case scenario) when preemption call is received, the signal shall go into an all red sequence. After the all red clearance, the track clearance phase will then get a left turn green arrow with a green ball indication. This will allow the track clearance phase a protected left turn movement and eliminate a left turn trap condition.

A battery backup system should be installed and utilized on all new traffic signals that have railroad preemption.

Glossary

Interconnection – The electrical connection between the railroad active warning system and the traffic signal controller assembly for the purpose of preemption.

Advance Preemption and Advance Preemption Time – Notification of an approaching train is forwarded to the highway traffic signal controller unit or assembly by railroad equipment for a period of time prior to activating the railroad active warning devices. This period of time is the difference in the Maximum Preemption Time required for highway traffic signal operation and the Minimum Warning Time needed for railroad operation and is called the Advance Preemption Time.

Simultaneous Preemption – Notification of an approaching train is forwarded to the highway traffic signal controller unit or assembly and railroad active warning devices at the same time.

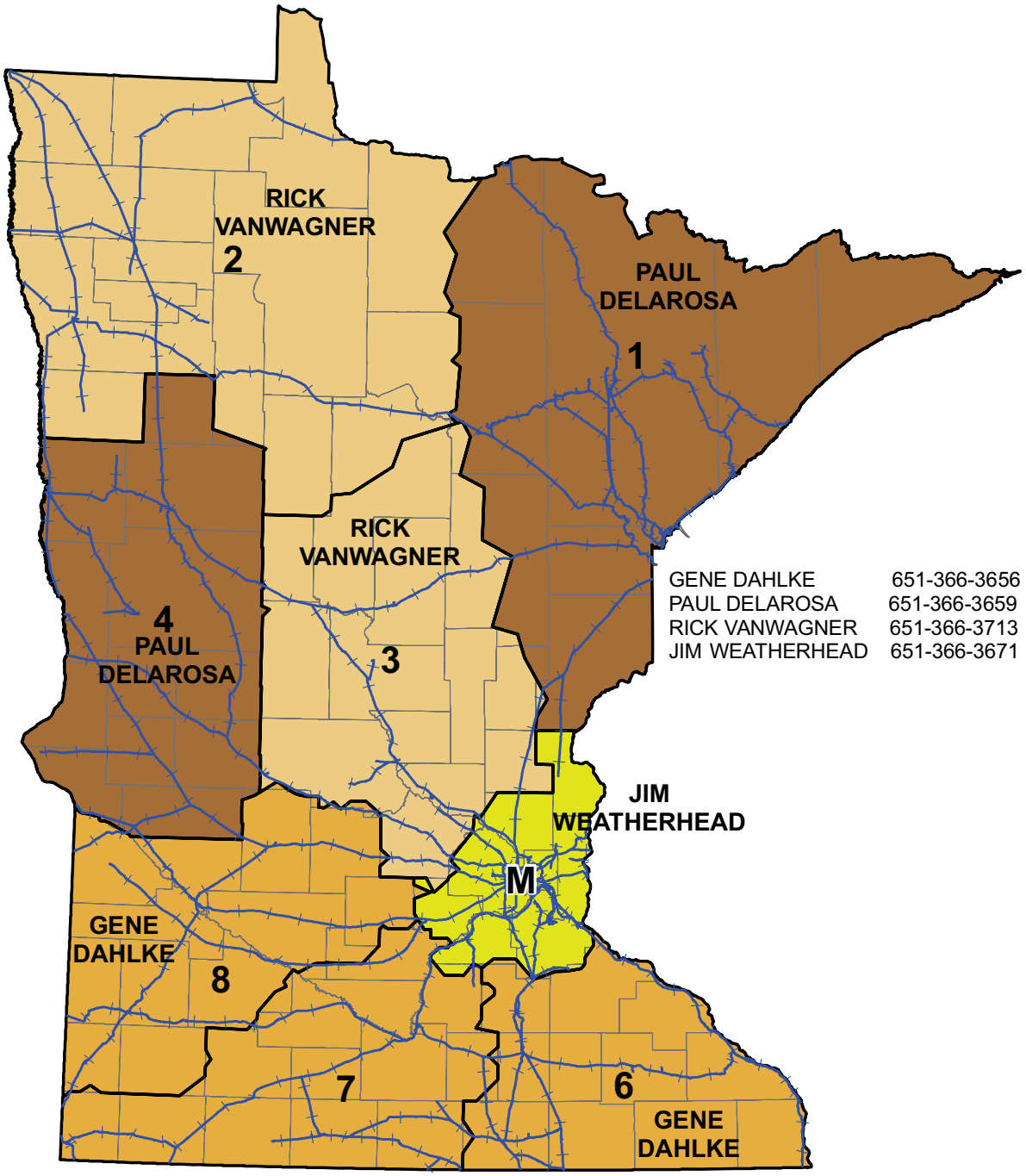
Maximum Preemption Time – The maximum amount of time needed following initiation of the preemption sequence for the highway traffic signals to complete the timing of the Right-of-Way Transfer Time, Queue Clearance Time and Separation Time.

Double Break Interconnect Circuit – A six-wire interconnection circuit between the signal controller cabinet and the railroad bungalow equipment. One pair of wires carries power to the railroad bungalow. The second pair comes back to the signal cabinet hot when there is no preempt call present and the third pair comes back cold. When there is a preempt call, the hot and cold pairs reverse. If for some reason this arrangement fails and both become hot or cold simultaneously the intersection will go to flash.

HANDOUT

Railroad-Highway Projects

RAIL ADMIN. Project Managers



GENE DAHLKE	651-366-3656
PAUL DELAROSA	651-366-3659
RICK VANWAGNER	651-366-3713
JIM WEATHERHEAD	651-366-3671

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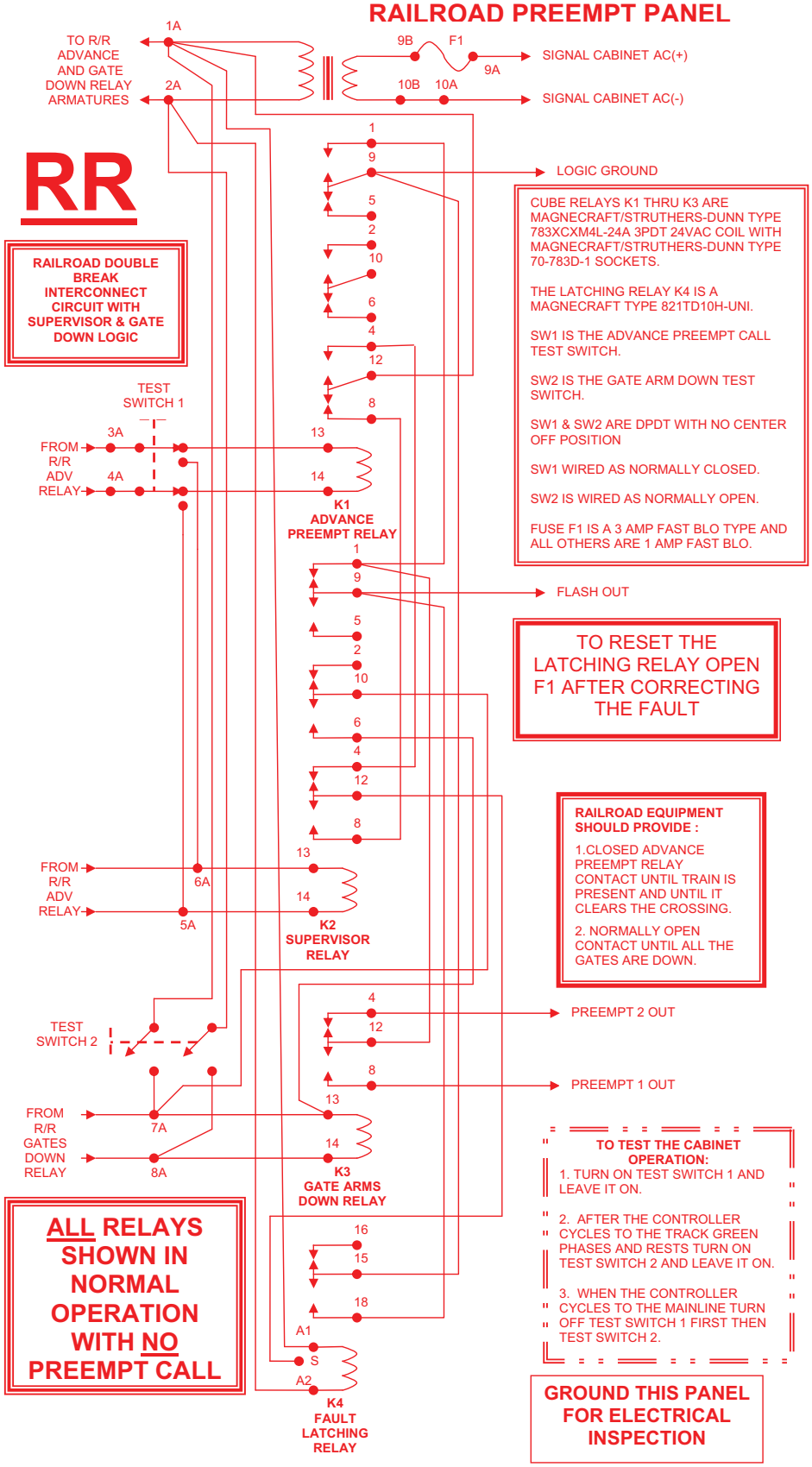
This circuit updated 1-18-08 on the Memo

RAILROAD PREEMPT PANEL



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12. SAMPLE PLAN SETS

The plan set following this page is a handout taken from the OTST web site. A copy of this (in MicroStation dgn format) can be found at:

www.dot.state.mn.us/trafficeng/signals/signalplansheets.html

Note: It is recommended that you review all original reference material.

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13. APPENDIX

13.1 GLOSSARY OF TERMS

Actuation - The presence of a vehicle or pedestrian as indicated by an input to the controller from a detector. The action of a vehicle or pedestrian which causes a detector to generate a call to the signal controller.

Added Initial Portion - An amount of time added to the minimum initial green time to accommodate to vehicles which arrived during the preceding red.

All-red - An interval during which all signal indications at an intersection display red indications.

Approach - All lanes of traffic that enter the intersection from the same direction.

Bell End - The end of a piece of rigid PVC conduit that flares out to allow connection of an additional piece of conduit.

Call - A demand for service registered in a controller. A call indicates a vehicle or pedestrian is waiting for a green indication.

Clearance Interval(s) - The interval(s) from the end of the right-of-way of one phase to the beginning of a conflicting phase. This is usually the yellow plus any all red phase.

Controller (or Controller Unit) - The device that determines which signal indications are to be illuminated at any given time. The controller is usually located in a cabinet near the intersection.

Cycle length - The time taken for a complete sequence of all phases at an intersection. This time is counted from the start of green for any phase until that same phased is started again. Pretimed cycle lengths do not vary, but actuated cycle lengths so because of phases skipped, extensions, etc.

Delay - Time lost while traffic impeded in its movement by some element over which it has no control. Usually expressed in seconds per vehicle.

Detector - A device that provides an input to the controller to indicate that a vehicle or pedestrian is present.

Dial Up Controller Operation - The operation of a controller unit at an intersection using a modem for direct dial up(telephone) communication.

End Bell - The rigid PVC conduit fitting that is glued on at the end of a conduit to protect the conductors during pulling operations.

Extensible Portion - That variable-length part of the green interval which follows the initial portion.

Extension Limit - The maximum time allowed for the extensible portion of the green.

Free Flow - Traffic flow which is not impeded.

Force Off - A command that will force the termination of the right-of-way.

Full Traffic-Actuated Controller Unit - A type of traffic-actuated controller unit which accommodates for traffic actuation on all approaches to the intersection.

Gap - The interval in time or distance from the back of one vehicle to the front of the following vehicle.

Gap Reduction - A feature whereby the "unit extension" or allowed time spacing between successive vehicle actuation on the phase displaying the green in the extensible portion of the interval is reduced.

Green Interval - The right-of-way portion of a traffic phase.

Headway - The distance or (usually) time between vehicles measured from the front of one vehicle to the front of the next.

Hold - A command that retains the existing right-ofway.

Initial Portion - The first part of the green interval for a phase, which is not affected by actuation received during the green interval for that phase.

Intersection Leg - The roadways entering or leaving one side of the intersection.

Interval - Any one of the several divisions of the cycle during which signal indications do not change.

Interval Sequence - The order of appearance of signal indications during successive intervals of a cycle.

Isolated Controller Unit Operation - the operation of a controller unit at an intersection without master supervision dial-up communication.

Last Car Passage - A feature that allows a non-reduced passage period for the last vehicle extending the green during gap reduction.

Locking - A mode of a controller phase in which a call is retained by the controller even if the vehicle leaves the detector.

Loop - Wire induction loop, the most-used detector in Minnesota.

Master Controller Unit - A controller unit for supervising a system of local intersection controllers.

Maximum Green - A longest period of green time allowed when there is a demand on an opposing phase.

Minimum Green - The shortest green time allowed a phase.

Non-locking - A mode of actuated-controller-unit operation which will not retain a call if the calling vehicle leaves the detector.

NRTL - Nationally Recognized Testing Laboratory

Offset - The relationship in time between a point in the cycle at a particular intersection and a similar point in the cycle at another intersection or reference.

Overlap - A traffic phase that services two or more traffic phases at the same time.

Passage Period - The time allowed for a vehicle to travel at a selected speed from the detector to the nearest point of conflicting traffic, i.e. from the detector into the intersection.

Pedestrian Clearance Interval - The first clearance interval following the pedestrian walk interval, normally symbolized by the flashing "HAND". The pedestrian clearance interval shall allow a pedestrian, who has already begun to cross time to reach the far side of the roadway or a safe refuge. A pedestrian shall not begin to cross during this interval.

Pedestrian Signal Head - A 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 a pedestrian signal housing and a pedestrian signal indication that fits within the housing.

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.

Pedestrian Phase - A traffic phase allocated exclusively to pedestrian traffic.

Pedestrian "WALK" Interval - the controller interval during which the "WALK", symbolized by the "WALKING PERSON", indications of the pedestrian signals are illuminated. Generally the interval is 4 to 7 seconds in length during which the pedestrian begins to cross the roadway.

Permissive Period - The time period in which the controller unit is allowed to leave a coordinated phase under coordinated control and go to other phases.

Phase - The part of a cycle allocated to any combination of traffic movements receiving the right-of-way simultaneously during one or more intervals, i.e. a left turn phase.

Phase Omit (Special skip, Force skip) - A command that causes omission of a phase.

Portion - A discrete subdivision of an interval during which the signals do not change.

Pre-emption - The transfer of the normal control of signals to a special signal control mode, i.e. to accommodate emergency vehicles.

Pre-Timed Controller Operation - A method for operating traffic signals where the cycle length, phases, green times, and change intervals are all preset.

Red Clearance Interval - An interval which follows the yellow change interval during which no green indication is shown on any conflicting phase.

Rest - The state in which a controller unit rests until called out of the phase.

Secondary Controller Operation (Slave) - A method for operating the traffic signals under the supervision of a master controller.

Semi-Traffic-Actuated Controller Operation - a type of traffic operation in which means are provided for traffic actuation on one or more but not all approaches to the intersection.

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

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.

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

Source of Power (SOP) - Is the electric utility transformer.

Spacing - The interval in distance from head to head of successive vehicles.

Split - A division of the Cycle allocated to each of the various phases (normally expressed in percent).

Traffic Control Signal (Traffic Signal) – Any highway traffic signal by which traffic is alternately directed to stop and permitted to proceed.

Traffic Phase - A part of the cycle allocated to any traffic movements receiving the right-of-way or to any combination of traffic movements receiving the rightof- way simultaneously during one or more intervals.

Variable Initial - A controller function consisting of the capability of adding initial green time to the minimum green.

Vehicle Extension - see Passage Time.

Vehicular Phase - A traffic phase allocated to vehicular traffic.

Walk Interval - The portion of a Traffic Phase that permits pedestrians to leave the curb.

Yellow Change Interval - The first interval following the green right-of-way interval in which the signal indication for that phase is yellow, indicating that the right-of-way for that phase is about to terminate.

Yield - See Permissive Period.

13.2 SAMPLE SPECIAL PROVISON

The sample Special Provisions following this page are a handout taken from the OTST web site. A copy of this (in MSWord format) can be found at:

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

Note: Always obtain the latest version of the sample Special Provisions. Modify the sample (boilerplate) by removing the items that are not needed.

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SAMPLE" SIGNAL SYSTEM SPECIAL PROVISIONS (March 03, 2014)

This "sample" set of Signal System Special Provisions will require editing (add, delete, modify, update, etc.) prior to use on a specific project.

DIVISION SS

The following paragraph is required for all MnDOT or State Aid project contracts. ***All RED text must be removed from the special provisions prior to the Special Provisions being submitted for project letting.***

SS-1 (1802) QUALIFICATION OF WORKERS

The provisions of MnDOT Specification 1802 are hereby supplemented with the following:

Required Signal and Lighting Certification for all Contractors, Supervisors or Foremen involved in the field installation of the Traffic Signal and/or Lighting portion of this Project. Signal and Lighting Certification is available through the MnDOT Office of Traffic, Safety, and Technology (OTST). Questions regarding certification or past certification may be directed to the MnDOT Office of Traffic, Safety, and Technology (OTST) at Telephone No. (651) 234-7055.

Provide certified Contractor personnel on the Project work site at all times to perform or directly supervise the installation of a Traffic Signal System or a Lighting system.

SAMPLE" SIGNAL SYSTEM SPECIAL PROVISIONS (March 03, 2014)

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SS-2 (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 the applicable provisions of MnDOT 2565; current edition of the National Electrical Code; Plans; and as follows:

SS-2.1 GENERAL

A. 2565 Definitions

Definitions are in accordance with 2565.1B and as follows:

1. **Pedestrian Signal Head**
A 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 a pedestrian signal housing and a pedestrian signal indication that fits within the housing.

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

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

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4. **Signal Head**
Is an assembly of one or more signal sections that is provided for controlling traffic movements. This assembly of signal sections also includes a background shield. When used to control vehicles.

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

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.

7. **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.

8. **Bell End**
The end of a piece of rigid PVC conduit that flares out to allow connection of an additional piece of conduit.

9. **End Bell**
The rigid PVC conduit fitting that is glued on at the end of a conduit to protect the conductors during pulling operations.

B. 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 signal cabinets 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 signal cabinet (one set = 1 anchor rod, nut, and washer).

3. One (1) 4-section rubber gasket to be installed by the Contractor between the bottom of each traffic signal cabinet and the concrete foundation.

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SAMPLE" SIGNAL SYSTEM SPECIAL PROVISIONS (March 03, 2014)
This "sample" set of Signal System Special Provisions will require editing (add, delete, modify, update, etc.) prior to use on a specific project.

(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 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.

C. Installation of Department Provided Materials

Install the Department provided traffic signal cabinets each complete with actuated controller unit and all required signal control equipment described in (B) above.
Provide and install all additional materials and electrical equipment for a complete operating traffic 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 signal cabinet as directed by the Engineer to make each traffic control signal system 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 TO THE DISTRICT HEADQUARTERS.

D. Pick Up Department Provided Materials

Pick up materials and electrical equipment described in (A) above at the MnDOT Central Electrical Services Unit, 6000 Minnehaha Avenue, St. Paul, MN. 55111. Follow these requirements:

1. Request from the Central Electrical Services Unit the materials and electrical equipment listed in (A) above.
2. Direct the Central Electrical Services Unit to refer to T.E. Request No. _____.
3. Request Department provided materials at least thirty (30) normal working days in advance of the time material is needed on the project.
4. Notify Mr. Jim Deans of the MnDOT Central Electrical Services Unit (Telephone 651-366-5753) at least three (3) normal working days in advance of intention to pick up materials and electrical equipment.

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5. Pick up the Department provided materials and electrical equipment at the above specified location and transport them to the job site.
6. Secure cabinet in an upright position when transporting to the job site. Ensure that the cabinets will not tip and be damaged.
7. NOTIFY THE ENGINEER IN ADVANCE OF CONTACTING MR. DEANS.

E. Signal Agreements

The Minnesota Department of Transportation (MnDOT) will execute a Traffic Control Signal Agreement for the work under this Contract. MnDOT approval of any and all changes, supplements to the Contract, and/or change orders to this Contract which will affect cost participation in the signal construction is contingent upon the execution of appropriate procedures necessary to satisfy the terms and conditions of said agreement.

F. Shop Drawings

PROVIDE SHOP DETAIL DRAWINGS FOR MATERIALS AND ELECTRICAL EQUIPMENT AS SPECIFIED IN THE CONTRACT DOCUMENTS.

The following text should be used when the District wants GPS coordinates provided on all newly installed infrastructure:
All Red text must be removed from the special provisions prior to the special provisions being submitted for project letting.

G. Global Positioning System (GPS) Component and Utility Location Data

Collect location coordinates for each traffic signal pole, service cabinet, traffic signal cabinet, source of power, handholes and underground cable, including cable installed in conduits and empty conduits using a GPS receiver capable of sub-meter accuracy. Location data must meet the following criteria:

1. The collected coordinates should be accurate to less than one meter.
2. Use a minimum of 5 satellites by the receiver to collect location data.
3. UTM15N or WGS84 are preferred coordinate systems.

Measure Above ground components from the street side of the asset collected.

Collect underground cable location no more than 2 weeks after it has been installed. Collect underground cable as line geometry. Capture the vertex points every 100 feet and at every junction or change in cable direction. Depth does not need to be collected unless underground cable is installed outside the depth of 2 feet as specified by 2565.3Db. If depth change has occurred, capture a vertex point before and after the depth change.

If GPS coordinates are required for in place underground facilities capturing the coordinates based

SAMPLE" SIGNAL SYSTEM SPECIAL PROVISIONS (March 03, 2014)
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on recent above ground utility locate markings would be acceptable.

Data that does not meet the above criteria and guidelines may be rejected and the contractor would be responsible to repeat the data collection.

Provide the system component and utility location data in an electronic, standard geospatial vector data format. Obtain MnDOT acceptance of the format prior to commencement of field work.

Completing and submitting the system component and utility location data is considered incidental work.

SS-2.2 MATERIALS

A. Conduit

Provide one of the following types of conduits; Rigid Steel Conduit (R.S.C.), Rigid Polyvinyl Chloride Conduit (P.V.C.), or Continuous Length Conduit (HDPE).

Provide the correct conduit size~~d~~ as indicated in the Plan.

Provide conduit meeting the following requirements:

1. Rigid Steel Conduit (RSC) in accordance with 3801.

2. Rigid (PVC) and Continuous Length Conduit (HDPE) in accordance with MnDOT 3803 meeting the following requirements:

(2.1) Appropriate conduit fittings for use with HDPE continuous length conduit.

(2.2) Capable of being installed by stitching, plowing, trenching, or directional boring methods.

(2.3) Marked on the outside of conduit indicating the following:
   a. Manufacturer's name
   b. Size of conduit
   c. Type of conduit (HDPE, etc.)
   d. NRTL Certification Mark
   e. Any other markings required by the N.E.C.

Provide either rigid steel conduit (R.S.C.) or rigid polyvinyl chloride conduit (P.V.C.) conduit from concrete foundations to the nearest handhole.

B. Roadway Loop Detector Conductors

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Provide roadway loop detector conductors in accordance with 3815.2B.2 and as follows:

1. Loop detector conductors for use in rigid PVC conduit in full compliance with the requirements of International Municipal Signal Association (IMSA) 51-3.

2. Loop detector conductors for roadway embedded saw-cut loop detectors in full compliance with the requirements of International Municipal Signal Association (IMSA) 51-7.

(2.1) No binding of the inner insulated loop conductor and the outer encasing tube is permitted.

C. Handholes

2565.2C is hereby deleted and the following is substituted therefore.

C Handholes
Only use handholes for non-deliberate heavy vehicular traffic unless otherwise indicated in the Plans.

C1 Handholes Non-Deliberate Heavy Vehicular Traffic
Only use Department-approved handholes listed on the Approved/Qualified Products List under "Signals."

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.

C2 Handholes Deliberate Heavy Vehicular Traffic
Only use handholes in accordance with Standard Plate 8117 which are in full compliance with Article 314.30 of the NEC and listed and labeled by a NRTL in accordance with the current edition of ANSI/SCTE77 "AASHTO H-20 Deliberate Vehicular Traffic Applications".

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.

D. Mast Arm Pole Standards and Luminaires

Provide mast arm pole standards and luminaires in accordance with the provisions of MnDOT 3831, and as follows:
Include the following if the District intends to use LED Roadway luminaires on the project. This luminaire is intended as a 250 watt HPS Cobra Head replacement.
All Red text must be removed from the special provisions prior to the special provisions being submitted for project letting.

SAMPLE" SIGNAL SYSTEM SPECIAL PROVISIONS (March 03, 2014)
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1. LED Roadway Luminaires 40 Foot Mounting Height

Provide and install MnDOT approved LED Roadway Luminaires for mounting at 40 feet as specified herein and in the Plan.

MnDOT approved LED Roadway Luminaires for mounting at 40 feet are listed on the MnDOT Approved/Qualified Products Lists WEB site for Lighting:

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

Delete the following paragraph if LED Luminaires are used on the project.
All Red text must be removed from the special provisions prior to the special provisions being submitted for project letting.

2. Luminaires

Provide cobra head, 250 watt, 120 Volt, High Pressure sodium (HPS) luminaires (without photocell receptacle). Use Luminaires listed on the MnDOT Approved/Qualified Products List under Lighting:

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

3. Transformer Bases

Provide transformer bases in accordance with 3831.2B and as follows:

Attach no appurtenances (such as pedestrian push buttons, signs, etc.) to the transformer base that requires the drilling of holes in the transformer base.

4. Stainless Steel Woven Wire Cloth

Provide a stainless steel woven wire cloth around the opening at the bottom of the transformer base to the satisfaction of the Engineer with the following characteristics:

(4.1) 5 x 5 per inch mesh
(4.2) .041 inch wire diameter
(4.3) .159 inch opening width
(4.4) 63.2% open area

Install Stainless Steel Woven Wire Cloth as follows:

(4.5) Insert and wind around the transformer base opening (see pictures elsewhere in these Special Provisions) to prevent rodent entry.
(4.6) Cut even and smooth and secure flush with self-tapping screws to the upper edge of the transformer base opening.

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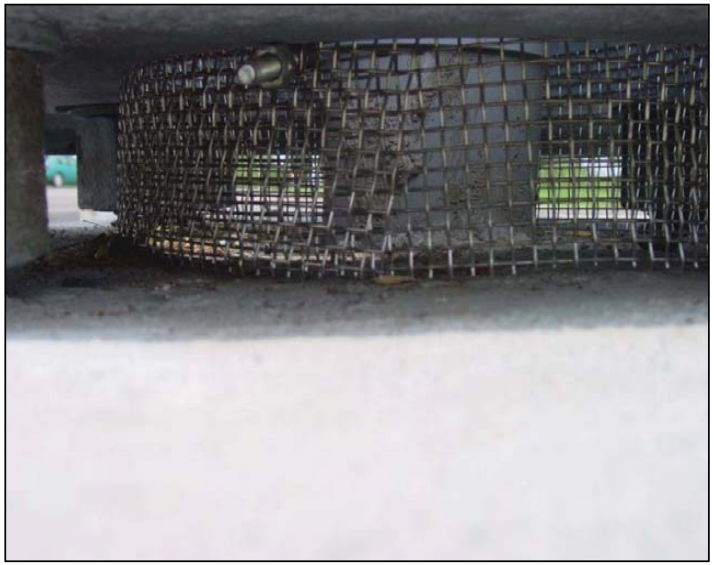
(4.7) Connect at the overlap with either a small stainless steel or brass bolt and nut assembly.

(4.8) Ensure that the woven wire cloth bottom edge is smooth, flush with the transformer base concrete foundation, ends overlap at least two (2) inches, and secured, in a manner, that does not allow movement.

(4.9) Ground the entire woven mesh assembly as required by the National Electrical Code (NEC).

OUTSIDE VIEW FROM TOP OF CONCRETE FOUNDATION TO OPENING IN THE BOTTOM OF THE TRANSFORMER BASE:



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SAMPLE" SIGNAL SYSTEM SPECIAL PROVISIONS (March 03, 2014)

This "sample" set of Signal System Special Provisions will require editing (add, delete, modify, update, etc.) prior to use on a specific project.

INSIDE TRANSFORMER BASE VIEW:

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E. Accessible Pedestrian Signals (APS) Pushbutton Bases

1. Provide APS pushbutton bases and shafts at locations indicated in the Plans and in accordance with the plans.

   Use MnDOT approved APS Pushbutton Bases listed on the MnDOT Approved/Qualified Products List WEB site under Signals:

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

2. Provide a quantity of four (4) 5/8 inch (UNC) stainless steel threaded rods, nuts and washers in accordance with MnDOT 3385.2D. for the anchors.

   (2.1) Rod length = 7 ½ ± ¼ inches.

   a. The top and bottom of the rod must have chamfered (rounded) edges to allow easy installation of the required nut.

   (2.2) Provide 1 nut and washer for each rod.

3. Provide APS pushbutton base adhesive anchoring systems to secure the stainless steel threaded rods into the concrete.

   Use MnDOT approved APS Pushbutton Base Adhesive Anchoring Systems listed on the MnDOT Approved/Qualified Products List WEB site under Signals:

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

Installation of the pedestrian pushbutton bases are specified in the Plan and elsewhere in these Special Provisions.

F. Traffic Signal Pedestals

Change the bolded aluminum to steel below if the signal system is going to be painted. In either case remove the bolded option from the text.

All RED text must be removed from the special provisions prior to the special provisions being submitted for project letting.

Provide **aluminum** traffic signal pedestal shafts and pedestal bases at the locations indicated in the Plans in accordance with the applicable provisions of MnDOT Standard Plate No. 8112, 8122, 8129, MnDOT 3832, and the following requirements:

1. Pedestal Reinforcing Collar (Wind Collars):

   Provide and install a pedestal reinforcing collar on each existing pedestal shaft without an

extended collar.

Use MnDOT approved Pedestal Reinforcing Collars listed on the MnDOT Approved/Qualified Products List WEB site under Signals:

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

Installation of the pedestal reinforcing collar is specified elsewhere in these Special Provisions.

The following language needs to be included if you are using pedestal shafts for mounting the ped head type 4A and APS button on a corner or if you are using signal head bracketing on the pedestal shaft.

All RED text must be removed from the special provisions prior to the special provisions being submitted for project letting.

2. Pedestal Slipfitter Collars:

   Provide pedestal slipfitter collars as specified in MnDOT 3832. Before ordering from the signal supplier, ascertain from the Engineer the number of required 1½ inch inside threaded hubs (side openings) in the pedestal slipfitter collar.
   Fabricate ornamental caps from aluminum.

If you are going to replace pedestal mounted signal heads and no longer use signal bracketing but rather use straight mount plumbizers than use the following paragraph instead of slipfitter collars

All RED text must be removed from the special provisions prior to the special provisions being submitted for project letting.

3. Pedestal Cap:

   Provide aluminum pedestal caps with an anodic coating as per MIL-A-8625C for Type II, Class I Coating atop each pedestal shaft when straight mount plumbizers are used for signal and pedestrian head mounting.

   The pedestal caps must be MnDOT approved pedestal caps as listed on the MnDOT Approved/Qualified Products List WEB site for Signals:

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

G. Angle and Straight Mount Caps

Provide angle and straight mount caps at locations as indicated in the Plan.

Use MnDOT approved angle and straight mount caps listed on the MnDOT Approved/Qualified Products List WEB site under Signals:

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

H. Threaded Hub and Flange Pole Adaptor

HANDOUT

SAMPLE" SIGNAL SYSTEM SPECIAL PROVISIONS (March 03, 2014)
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Provide threaded hub and flange pole adaptors at locations as indicated in the Plan.

Use MnDOT approved threaded hub and flange pole adaptors listed on the MnDOT Approved/Qualified Products List WEB site under 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. 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.

I. Blank

J. Cluster Head Adaptor

Provide Cluster head adaptors at locations as indicated in the Plan.

Use MnDOT approved cluster head adaptors listed on the MnDOT Approved/Qualified Products List WEB site under 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.

K. Bi Modal Green and Yellow Arrow Signal Indications

Provide green and yellow bi-modal signal indications at locations as indicated in the Plan.

Use MnDOT approved bi-modal signal indications listed on the MnDOT Approved/Qualified Products List WEB site under Signals:

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

The following language needs to be included if "pole base connectors" are being used as conductor termination devices. You must use either Pole Base Connectors or Terminal Bocks but not both.
All RED text must be removed from the special provisions prior to the special provisions being submitted for project letting.

L. Pole Base Connectors

Provide MnDOT approved 14AWG pole base connectors in accordance with MnDOT 2565.2W and as follows:

SAMPLE" SIGNAL SYSTEM SPECIAL PROVISIONS (March 03, 2014)
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Use pole base connectors in each pole base for terminating signal conductors to vehicle signal indications, pedestrian signal indications, and EVP confirmatory lights in accordance with the detail in the Plan.

The following language needs to be included if "terminal blocks" are being used as conductor termination devices. You must use either Pole Base Connectors or Terminal Bocks but not both.
All RED text must be removed from the special provisions prior to the special provisions being submitted for project letting.

M. Terminal Blocks

Provide terminal blocks in accordance with the provisions of MnDOT 2565.2V.

N. 2565.2F.4K Revision

2565.2F.4K is hereby deleted and the following is substituted therefore.

Vehicle Signal Heads.

O. Blank

P. 2565.2F.4L Revision

2565.2F.4L is hereby deleted and the following is substituted therefore.

Pedestrian Signal Heads.

Q. 3834 Revision

3834 is hereby deleted and the following is substituted therefore.

3834 VEHICLE SIGNAL HEADS

3834.1 SCOPE
Provide standard traffic signal heads to control vehicle movements as part of a traffic control signal system or freeway ramp control signal.

3834.2 REQUIREMENTS

A Standard ITE Vehicle Signal Heads

A.1 General
Use standard ITE black polycarbonate vehicle signal housings listed on the Approved/Qualified Products List under "Signals," unless otherwise required by the contract. Verify that the electrical and optical system of each vehicle signal indication is designed to operate on a nominal 120 VAC, single phase power supply.
Use adjustable-type vehicle signal housings capable of 360° rotation about a vertical axis.

Use vehicle signal heads made up of at least three separate vehicle signal sections. Ensure each vehicle signal section consists of a housing, housing door, visor, optical unit, and wiring.

Use signal indications for traffic control signal systems of the nominal size as required by the contract.
Arrange vehicle signal sections in a vehicle signal head in accordance with Part IV, "Signals" of the MN MUTCD.

For each intersection, install standard ITE vehicle signal heads from the same manufacturer.

Install and mount each vehicle signal head at the location shown on the plans.

Always provide vehicle signal heads with provisions to attach a background shield, regardless of the contract requirement for background shields.

A.2 Visor
Provide each signal section of each signal head with a removable visor. Use visors meeting the following characteristics:

(1) Made from black polycarbonate material,
(2) Designed to fit tightly against the housing door to prevent filtration of light between the visor and the housing door,
(3) At least 9½ in [240 mm] long for a nominal 12 in [300 mm] vehicle signal indication, and
(4) At least 7 in [180 mm] long for a nominal 8 in [200 mm] vehicle signal indication.

Mount the visor with twist-on slots and stainless steel screws positioned for vertical or horizontal mounting of the signal section, and with a downward tilt of at least 3.5°.

For traffic control signal system heads, provide tunnel-type visors that enclose 80 percent of the lens circumference.

A.3 Light Emitting Diode (LED) Indications
Use LED signal indications listed on the Approved/Qualified Products List for "Signals" and as required by the contract.

A.4 Background Shield
Provide and attach background shields to vehicle signal heads unless otherwise required by the contract.

Use black polycarbonate background shields that extend at least 5 in [125 mm] on each side of the vehicle signal head and at least 4 in [100 mm] at the top and bottom.

Do not cut the bottom of a background shield attached to a vehicle signal head, mounted directly above a pedestrian signal head. For this case when using pipe bracketing, install a length of pipe

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nipple, threaded on both ends above the pedestrian signal head to allow the separate rotation of the vehicle signal head and the pedestrian signal head.

Provide background shields with a nonflective black, dull finish. Attach background shields to vehicle signal heads so no background light shows between the shield and the vehicle signal head.

B Mounting Vehicle and Pedestrian Signal Heads
Mount vehicle and pedestrian signal heads using straight, angle, or two-way plumbizer signal mounts. Provide signal head mounts and required appurtenances for mounting vehicle and pedestrian signal heads to mast arms, vertical pole shafts, and pedestal shafts in accordance with the contract requirements.

Use straight, angle, or two-way plumbizers listed on the Approved/Qualified Products List under "Signals."

Provide four and five-section signal heads and signal head mounting spacers at the point of mounting to the plumbizer.

Use signal head mounting spacers listed on the Approved/Qualified Products List under "Signals."

If the contract requires signal brackets and pipe fittings for mounting vehicle and pedestrian signal heads, provide signal brackets and pipe fittings in accordance with the following:

(1) Use nominal 1½ in [40 mm] diameter standard anodized aluminum pipe signal bracket and pipe fitting for signal brackets and pipe fittings for mounting vehicle and pedestrian signal heads.
(2) Provide signal brackets long enough to provide vehicle and pedestrian signal head alignment, to allow programming of optically programmed vehicle signal heads, or of a length directed by the Engineer.
(3) Provide locknuts, nipples, locknipples, gaskets, washers, and other hardware used to fasten vehicle and pedestrian signal heads to signal bracketing and pipe fittings, fabricated of anodized aluminum and traffic signal industry standard signal hardware.
(4) Mount signal brackets and pipe fittings plumb or level, symmetrically arranged, and securely assembled.
(5) Construct signal brackets and pipe fittings to conceal traffic signal conductors, watertight, and free of sharp edges or protrusions to prevent damage to the traffic signal conductor insulation.

3834.3 SAMPLING AND TESTING
Do not install the material specified in this section until approved by the Engineer.

R. 3835 Revision

3835 is hereby deleted and the following is substituted therefore.

HANDOUT

3835 PEDESTRIAN SIGNAL HEADS

3835.1 SCOPE
Provide pedestrian signal heads to direct pedestrian movements as part of a traffic control signal system.

3835.2 REQUIREMENTS

A General
Use standard ITE black polycarbonate pedestrian signal housings listed on the Approved/Qualified List under "Signals," unless otherwise required by the contract.

Provide LED modules for pedestrian signal indications with countdown timers listed on the Approved/Qualified Products List under "Signals."

B Signal Brackets and Pipe Fittings..... 3834.2.C

3835.3 SAMPLING AND TESTING..... 3833
Submit four sets of manufacturer's drawings, warranty information, and the product invoice, to the Engineer for approval.

S. Vehicle Signal Heads

Provide all new vehicle signal heads in accordance with the applicable provisions of MnDOT 3834, and as follows:

Provide and install a metal support plate (supplied by the signal head Manufacturer) on the inside of the signal section at the attachment point of the straight or angle mount plumbizers (one plate each for inside the upper and lower signal section at the attachment point).

Use either straight or angled mounts in accordance with these special provisions and as detailed in the Plan.

Provide and install the required through-bolts for connecting the individual sections.

Fasten together the sections above or below the straight or angled mount by means of a noncorrosive 3-bolt mounting assembly. Use locknuts for the 3-bolt mounting assembly to prevent the assembly from loosening.

For each LED signal indication, submit to the Engineer, for approval, four copies of all warranty information indicating the required 5-year warranty period (from date of installation), product invoice, and documentation indicating name of manufacturer, model number, and serial number .

After approval, the Engineer will distribute the drawings to the following:

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1. MnDOT Central Electrical Services Unit (Non-Metro Projects Only), or
   MnDOT Metro Electrical Services Unit (Metro Projects Only).
2. MnDOT Traffic Electrical Systems Engineer.
3. MnDOT District Traffic Engineer.
4. City of _____ or County of_____.

Affix to the back of each "LED" signal indication a permanent label, or permanently marked (utilizing an "oil based paint marker") with the actual date of installation to the satisfaction of the Engineer. Use an oil based paint marker of a contrasting color to ensure that the date can be easily read.

T. Pedestrian Signal Heads with Countdown Timers

Provide poly-carbonate pedestrian signal housings with pedestrian signal indications which include countdown timers in accordance with MnDOT 3835 and as follows.

Provide, to the Engineer, four (4) copies of product documentation as required by MnDOT 3835. After approval, the Engineer will distribute the drawings to the following:

1. MnDOT Central Electrical Services Unit (Non-Metro Projects Only), or
   MnDOT Metro Electrical Services Unit (Metro Projects Only).
2. MnDOT Traffic Electrical Systems Engineer.
3. MnDOT District Traffic Engineer.
4. City of _____ or County of_____.

The following language needs to be included if "Accessible Pedestrian Signals (APS)" are being designed in the signal system. When designing the signal plan the two (2) Accessible Buttons on a given corner must not be placed on the same pole. Use of the replaceable pedestrian station detail for mounting the second Button is required. You must use Accessible Pedestrian Signal (APS) Push Button Stations when the signal system is providing Pedestrian access.
All RED text must be removed from the special provisions prior to the special provisions being submitted for project letting.

U. Accessible Pedestrian Signals (APS) – (Audible Pedestrian Push Button Units and Associated Traffic Signal Cabinet Equipment)

Provide Accessible Pedestrian Signals in accordance with MnDOT 3833 and as follows:

The APS 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 Central Electrical Services unit on one of the following media types:
Compact Disk
USB flash drive.

Deliver all Accessible Pedestrian Signals (APS) components, except push button units, to the MnDOT

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Central Electrical Services Unit for installation into the Department provided traffic signal cabinet. Deliver the components being installed in the traffic signal cabinet to the above location at least thirty (30) normal working days in advance of when the department provided traffic signal cabinet is required on the job site.

Ensure that the order form below is presented to the Accessible Pedestrian Signal (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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SAMPLE" SIGNAL SYSTEM SPECIAL PROVISIONS (March 03, 2014)

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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 _____ (Street Being Crossed) **at** _____ (Intersecting Street)

Walk Message:
_____ (Street Being Crossed) **Walk sign is on to cross** _____ (Street Being Crossed)

PB2-4

Wait Message:
Wait to Cross _____ **at** _____

HANDOUT

SAMPLE" SIGNAL SYSTEM SPECIAL PROVISIONS (March 03, 2014)

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(Street Being Crossed) (Intersecting Street)

Walk Message:
_____ (Street Being Crossed) **Walk sign is on to cross** _____ (Street Being Crossed)

PB4-1

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)

PB4-2

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)

PB4-3

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)

PB4-4

HANDOUT

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SAMPLE" SIGNAL SYSTEM SPECIAL PROVISIONS (March 03, 2014)

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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)

PB6-1

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)

PB6-2

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)

PB6-3

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)

PB6-4

Wait Message:
Wait to Cross _____ **at** _____

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SAMPLE" SIGNAL SYSTEM SPECIAL PROVISIONS (March 03, 2014)

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(Street Being Crossed) (Intersecting Street)

Walk Message:
_____ (Street Being Crossed) **Walk sign is on to cross** _____ (Street Being Crossed)

PB8-1

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)

PB8-2

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)

PB8-3

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)

PB8-4

Wait Message:
Wait to Cross _____ (Street Being Crossed) **at** _____ (Intersecting Street)

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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."

All RED text must be removed from the special provisions prior to the Special Provisions being submitted for project letting.

Include the following if the District intends to use pedestial shafts to mount APS buttons with Signal or Pedestrian Heads installed above.
All Red text must be removed from the special provisions prior to the special provisions being submitted for project letting.

V. Accessible Pedestrian Signal (APS) Pushbutton Mounting Spacer

Provide and install MnDOT approved Accessible Pedestrian Signal (APS) Pushbutton Mounting Spacers as specified herein and in the Plan.

MnDOT approved Accessible Pedestrian Signal (APS) Pushbutton Mounting Spacers are listed on the MnDOT Approved/Qualified Products Lists WEB site for Signals:

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

W. 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 signal cabinet and control equipment.

(TRAFFIC SIGNAL CABINET AND ASSOCIATED INTERNAL CONTROL EQUIPMENT TO BE PROVIDED BY THE DEPARTMENT AND INSTALLED BY THE CONTRACTOR.)

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SAMPLE" SIGNAL SYSTEM SPECIAL PROVISIONS (March 03, 2014)
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2. Signal Service Cabinet.

(SIGNAL SERVICE CABINET TYPE SSB TO BE PROVIDED AND INSTALLED BY THE CONTRACTOR)

X. 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 which includes an inverter, batteries, bypass switch and external strobe.

Y. 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 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 without battery backup equipment. Do not provide an inverter, batteries, bypass switch or external strobe.

Z. Crosswalk Pavement Markings (Preformed Pavement Marking Tape for Permanent Traffic Lane Delineation)

Provide (CROSSWALK MARKING-POLY PREFORM-GROUND IN) accordance with 2582.2A.
Install crosswalk block markings in accordance with 2582 and as follows:

1. Grove the block markings into the pavement surface to protect the marking from snow and ice removal operations.

   (1.1) See division S Special Provisions for installation requirements.

2. Mobile retroreflectometer measurements (MRM) are not required for crosswalk block markings.

Providing and applying of new pavement markings is considered incidental work and no direct compensation will be made therefore.

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AA. Advance Warning Flashers (AWF)

Provide and install all materials and electrical equipment to provide four (4) complete operating advance warning flashers (Signal Base No.'s __, __, __, and __) at the locations indicated in the Plans in accordance with the "ADVANCE WARNING FLASHER DETAILS" in the Plans and with the following:

Change the bolded aluminum to steel below if the signal system is going to be painted. In either case remove the bolded option from the text.
All RED text must be removed from the special provisions prior to the special provisions being submitted for project letting.

1. Pedestal Shaft:

   (1.1) **Aluminum** shaft in accordance with Standard Plate 8122.

   (1.2) Meets or exceeds current American Association of State Highway and Transportation Officials (AASHTO) breakaway requirements.

   (1.3) Provide test reports from a Federal Highway Administration (FHWA) approved independent laboratory certifying that the pedestal base is tested and meets all requirements.

   (1.4) Supply from the manufacturer a statement of certification from the FHWA stating such tests have been accepted and approved.

2. Anchor Rods:

   Anchor rods, nuts, and washers must conform to the requirements of MnDOT Standard Plate No. 8112 and must be galvanized full length in accordance with the provisions of MnDOT 3392.

3. Pedestal Washers:

   Provide pedestal washers in accordance with MnDOT Standard Plate No. 8129.

4. Pedestal Shims

   (4.1) Each leveling shim must be in accordance with MnDOT Standard Plate No. 8129.

   (4.2) Provide "U" shaped galvanized steel pedestal shims to plumb traffic signal pedestals. The pedestal shims shall be in accordance with Standard Plate 8129.

5. Pedestal Bases with Extended Collar and Pedestal Reinforcing Collars (Wind Collars)

   Provide either a pedestal base with an extended collar or a pedestal reinforcing collar on each

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pedestal shaft in accordance with Standard Plate 8122.

(5.1) Pedestal Reinforcing Collar(Wind Collars):

Provide and install a pedestal reinforcing collar on each pedestal shaft without an extended collar.

MnDOT approved Pedestal Reinforcing Collars are listed on the MnDOT Approved/Qualified Products List WEB site for Signals:

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

The installation of the pedestal reinforcing collar is specified elsewhere in these Special Provisions.

6. Pedestal Slipfitter Collars:

   (6.1) Provide aluminum pedestal slipfitter collars in accordance with MnDOT 3832 atop each pedestal shaft when a pedestrian signal indication is installed on the top of the pedestal shaft or when signal head bracketing is used.

   (6.2) Before ordering from the signal supplier, ascertain from the Engineer the number of required 1½ inch inside threaded hubs (side openings) in the pedestal slipfitter collar.

   (6.3) Fabricate ornamental caps from aluminum.

   (6.4) The Pedestal Slipfitter Collars and ornamental caps require an anodic coating per MIL-A-8625C for Type II, Class I Coating.

   (6.5) Fabricate ornamental caps from aluminum.

7. Flashing Beacon Assemblies:

   (7.1) Provide 12 inch, polycarbonate vehicle signal heads for flashing beacon assemblies. Fabricate vehicle signal sections, visors, and background shields with ultraviolet and heat stabilized black poly-carbonate materials that conform to I.T.E. requirements.

   (7.2) Use MnDOT approved Poly Carbonate Vehicle Signal Housings listed on the MnDOT Approved/Qualified Products Lists WEB site under Signals:

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

   (7.3) Provide and install a metal support plate (supplied by the signal head Manufacturer) on

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the inside of the signal section at the attachment point of the mount (one plate inside the head at the attachment point).

(7.4) Provide 12 inch "Yellow" signal indications in accordance with MnDOT 3834 and as follows:

(7.5) Affix to the back of each "yellow" flasher indication a permanent label indicating the date of installation to the satisfaction of the Engineer.

(7.6) Each flashing beacon assembly must include a cut away visor and background shield as indicated on the detail in the Plan.

(7.7) Attach flasher beacons to the advance warning flasher assembly as detailed in the Plans to the satisfaction of the Engineer.

8. Flashing Beacon Assembly Bracketing

Provide aluminum flashing beacon assembly bracketing with anodic coating as per MIL-A-8625C for Type II, Class I Coating.

9. Wiring at Each Advance Warning Flasher:

Provide a 4/c #14 signal control cable in accordance MnDOT 3815.2 between the terminal block or pole base connector in the pedestal base and each flashing beacon atop the advance warning flasher assembly.

10. Advance Warning Flasher Signs:

Provide and install W3-X4 (PREPARE TO STOP WHEN FLASHING) signs with each advance warning flasher installation. Fabricate the W3-X4 signs in accordance with MnDOT 2564, and as detailed in the Plans.

Provide sign base material and fabrication stickers that are in accordance with the applicable provisions of MnDOT 2564 and 3352. Sign face and sign legend materials must be Sign Sheeting for Rigid Permanent Signs, Delineators and Markers (Type IX or Type XI), except as specified below:

Sign face material must be fluorescent yellow reflective sheeting.

The retro reflective sheeting types and qualified products used for rigid permanent signs, markers and delineators can be found on the MnDOT Approved/Qualified Products Lists WEB site for Signing under Sheeting Materials.

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

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Mount each sign as detailed in the Plan to the satisfaction of the Engineer.

SS-2.3 CONSTRUCTION REQUIREMENTS

A. Sealing Open Ends of Conduits

2565.3D.2.b the last paragraph is hereby deleted and the following is substituted therefore.

Following installation of cables and conductors, seal the open ends of conduit entering cabinet's or pole foundations using duct seal compound NRTL classified under general use tapes.

B. Open Ends of Conduits

2565.3D.5.b is hereby deleted and the following is substituted therefore.

Immediately cap or plug the open ends of rigid PVC conduit to prevent the entrance of moisture until the installation of the electrical cables and conductors. Before installing electrical cables and conductors, provide rigid PVC conduit with standard PVC conduit end bells and end bells for HDPE continuous length conduit to prevent damage to the electrical cables and conductors.

C. Handholes

2565.3E is hereby deleted and the following is substituted therefore.

E Handholes
Install handholes as required by the contract and as approved by the Engineer. The Contractor may install additional handholes at no additional cost to the Department.

Set the tops of handholes so the cover is 1 in [25 mm] below grade, except in sidewalk areas, set the cover flush, or as directed by the Engineer.

To facilitate drainage, set handholes on a compacted aggregate drain bed, 4 ft [1.22 m] in diameter or square, and 12 in [300 mm] deep, using coarse filter aggregate in accordance with 3149.2.H, "Coarse Filter Aggregate."

Backfill handholes after installing the cover.

Drill conduit holes into the side walls of handholes no more than 1 inch larger than the size conduit being installed.

Conduits entering handholes must enter thru the barrel or side wall of the handhole.

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Remove excess material inside of existing handholes that are to be used in the new system.

After handhole and conduit installation at each handhole location, make the sidewalls inside handholes watertight by patching with concrete for pre-cast concrete handholes, or material-compatible caulking compound, or other sealing material, compatible handhole material, to the Engineer's satisfaction.

D. Concrete Foundations

2565.3 F.1 the second paragraph is hereby deleted and the following is substituted therefore.

If soil conditions allow, the Engineer may approve casting of foundations with rigid and securely braced forms or tubes only on the upper portion of the foundation. Brace entering conduits, anchor rods, ground rod electrodes, and other equipment in position with a rigid template and at the height necessary until the concrete cures. Do not remove forms or rigid template until the concrete cures.

E. Anchor Rods

2565.3 F.2 is hereby deleted and the following is substituted therefore.

Place the anchor rods in pole foundations in a rigid cage to maintain alignment while pouring the concrete as approved by the Engineer. Provide anchor rod cages designed without welding or tack welding on the anchor rods or as shown on the standard plate. The Engineer will reject anchor rods with welding or tack welding. Provide a template for the anchor rod projections. Leave the template in place until the concrete is cured. Do not begin work on the concrete foundation until the Engineer approves the anchor rods. The Engineer will reject foundations if anchor rods are improperly aligned after the concrete cures. Do not enlarge bolt holes in transformer bases to allow for shifted anchorages.

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.

F. Maintenance of Existing Electrical Systems

Maintain and keep in operation existing electrical systems in accordance with 2565.3B and as follows:

Except during any periods of authorized work suspension, the Contractor is responsible for locating all underground facilities of existing traffic 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 signal system facilities shall be transferred to the Contractor on the project start date as shown on the proposal.

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The MnDOT locating group will provide an initial locate of the underground traffic 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 the MnDOT Locating Office a minimum of four (4) working 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 the MnDOT locating office within two (2) hours of MnDOT's sending the Contractor's representative the locate request.

The Contractor responsible for locating all underground traffic signal system facilities will repair any damage as the result of improperly located or unmarked underground traffic signal system facilities within the project limits.

The repair of the damaged underground traffic 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.

It is the Contractor's responsibility to notify the MnDOT Locating Office to provide contact information and establish the contractor has assumed responsibility for locating MnDOT's underground traffic signal system facilities within the project limits. The form below shall be filled out by the Contractor's representative at the pre-construction meeting and the completed form should be sent to the following:

Marjean Townley (Dispatch)
Phone: (651)366-5750
Fax: (651)366-5742
E mail: Marjean.townley@state.mn.us
6000 Minnehaha Ave. St. Paul, MN 55111-4014

and

Jesse Knox (Supervisor)
Phone: (651)755-9061
Fax: (651)366-5742
E mail: jesse.knox@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:

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SAMPLE" SIGNAL SYSTEM SPECIAL PROVISIONS (March 03, 2014)

This "sample" set of Signal System Special Provisions will require editing (add, delete, modify, update, etc.) prior to use on a specific project.

Phone:
Fax:
E mail:
Address:

(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 _____

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SAMPLE" SIGNAL SYSTEM SPECIAL PROVISIONS (March 03, 2014)

This "sample" set of Signal System Special Provisions will require editing (add, delete, modify, update, etc.) prior to use on a specific project.

End Date _____

T.H. _____

Location _____

Lighting/ Signal Inspector _____

Contractor _____

Contractor (24 Hour Contact) _____

Project Manager _____

Phone Number _____

Fax Number _____

Email _____

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 Department will provide and maintain all items of the existing, temporary, and newly constructed traffic signal systems.

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In the event of an authorized work suspension the Contractor must supply 3 copies of an up to date accurate As Built drawing of the existing, temporary and newly constructed traffic signal systems to the Engineer prior to the work suspension. The As Built drawings shall be sent by the Engineer to the District Operations group, CESU/MESU and the MnDOT Locating Office.

PROVIDE TO THE DEPARTMENT CONTACT INFORMATION WITH NAMES AND TELEPHONE NUMBERS FOR 24 HOURS A DAY, 7 DAYS A WEEK MAINTENANCE AS DEFINED ABOVE.

The following language needs to be included if "pole base connectors" are being used as conductor termination devices. The District must use either Pole Base Connectors or Terminal Bocks but not both.
All RED text must be removed from the special provisions prior to the special provisions being submitted for project letting.

G. Mast Arm Pole Standard Installation
2565.3P is hereby deleted and the following is substituted therefore:

P Mast Arm Pole Standard Installation
Hoist mast arm pole standards into position without damage. Use two nuts and washers on each anchor rod to plumb the mast arm pole standards and to vertically position the pole surface opposite the arm. Do not enlarge or alter holes in the base plate to accommodate misaligned anchorages.

Use the following procedure to install mast arm pole standards on anchor rods:

(1) Place the transformer base access door 180 degrees from the mast arm.
(1.1) Attach no appurtenances (such as pedestrian push buttons, signs, etc.) to the transformer base that requires the drilling of holes in the transformer base.
(1.2) Place 100% clear silicone sealant between the pole base plate where it meets the transformer base top to ensure a moisture proof seal between the pole and the transformer base.

(2) Assemble and tighten the transformer base and pole in accordance with pole manufacturer instructions and AASHTO "Structural Supports for Highway Signs, Luminaires, and Traffic Signals" Sixth Edition 2013 or the most current version, Section "5.17.5.2-Anchor Bolt Pretensioning" and as follows:
(2.1) Clean exposed part of anchor rods with a wire brush or equivalent.
(2.2) Ensure clean anchor rods and that nuts spin freely along the entire length of all anchor rods.
(2.3) Lubricate anchor rod threads with brush-on anti-seize compound meeting the requirements of MIL-PRF-907E.
(2.4) Install and level heavy hex leveling nuts.
(2.5) Install first set of washers, place base or pole to anchor rod cluster, install second set of washers.
(2.6) Install and hand tighten heavy hex top nuts.
(2.7) Using "full force" and a standard 12 inch long wrench, or a few impacts of an impact wrench, tighten top nuts.

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(2.8) Using "full force" and a standard 12 inch long wrench, tighten leveling nuts.
(2.9) Mark positions of top nuts in relation to its adjacent bolt. Tighten top nuts as follows:

For PA85, 90, 100 and BA foundations
For anchor rods ≤ 1 ½ inches in diameter turn the nut one-third turn beyond tightening achieved in Steps 2.7 and 2.8.
For anchor rods > 1 ½ inches in diameter turn the nut one-sixth turn beyond tightening achieved in Steps 2.7 and 2.8.

For Pedestal foundations
For anchor rods ≤ 1 ½ inches in diameter turn the nut one-sixth turn beyond tightening achieved in Steps 2.7 and 2.8.
For anchor rods > 1 ½ inches in diameter turn the nut one-twelfth turn beyond tightening achieved in Steps 2.7 and 2.8.

(2.10) After 48 h, with the entire mast arm pole standard completely assembled and installed, check the tightness of the nuts. Follow step 2.7, step 2.8, and step 2. 9 for additional tightening.

(3) Provide and Install Stainless Steel Woven Wire Cloth in accordance with 3836 and as follows:
(3.1) Insert and wind around the transformer base opening to prevent rodent entry.
(3.2) Cut even and smooth and secure flush with self-tapping screws to the upper edge of the transformer base opening.
(3.3) Connect at the overlap with either a small stainless steel or brass bolt and nut assembly.
(3.4) Ensure that the woven wire cloth bottom edge is smooth, flush with the transformer base, concrete foundation. Ensure ends overlap at least two (2) inches, and secured, in a manner, that does not allow movement.
(3.5) Ground the entire woven mesh assembly as required by the National Electrical Code (NEC).

Install mast arms, brackets, and other attachments to the vertical pole shaft without damage.

Repair and restore damaged areas to original condition as specified in the contract or as approved by the Engineer.
Repair damage to galvanized finish in accordance with ASTM A780 Annex A2. Only use zinc rich paints found on the Approved/Qualified Products List for "Signals".

H. Pole Base Connectors

Install pole base connectors in accordance with manufacturer's installation instructions, MnDOT 2565.3J.7, and in accordance with the detail in the Plan.

The following language needs to be included if "terminal blocks" are being used as conductor termination devices. The District must use either Pole Base Connectors or Terminal Bocks but not both.

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I. Terminal Blocks

Install terminal blocks in accordance with manufacturer's installation instructions and MnDOT 2565.3J.5.

J. Blank

Include the following if the District intends to use LED Roadway luminaires on the project. We are labeling LED Luminaires so the luminaire type can easily be identified from the ground. This luminaire is intended as a 250 watt HPS Cobra Head replacement.

All Red text must be removed from the special provisions prior to the special provisions being submitted for project letting.

K. LED Roadway Luminaires 40 Foot Mounting Height

1. Install the luminaire in accordance with the manufacturer's installation instructions. Tighten fitter bolts according to manufacturer's specification.

2. Label the luminaire with the installation date in accordance with 3810.2A. and as follows:

   (2.1) Place an additional date of installation on the bottom of the luminaire so it can be read from the ground underneath the luminaire.

   (2.2) Provide labels for the date of installation both inside and outside of the luminaire meeting the following requirements:

      a) Record the installation date on self-adhering label.

      b) Use machine printed numbers.

      c) Text which is ½ inch tall.

      d) Month/Year numeric format.

      e) Suitable for placement in wet locations.

      f) Paper based labels are not acceptable.

      g) Place inside of the luminaire and on the bottom outside of the luminaire so the label showing the date can be viewed from the ground below.

3. Label the bottom outside of the luminaire with the number 40. Position this label so it is easily viewed from the ground directly underneath the luminaire.

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MnDOT approved Labels are listed on the MnDOT Approved/Qualified Products Lists WEB site for Lighting:

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

Letters and numbers shall have a minimum stroke width of 0.35 inches.

L. Equipment Pad Concrete Foundation

Construct and install the equipment pad concrete foundation at the location staked by the Engineer and as detailed in the Plans.

Install the cabinet concrete foundation for the Department provided traffic signal cabinet and control equipment as part of the equipment pad concrete foundation using Department provided anchor rods, nuts, and washers to mount the cabinet.
The anchor rods must project above the concrete foundation to accommodate the13 mm (1/2 inch) thick gasket.
Install the Department provided rubber gasket sections between the bottom of each cabinet base and the concrete foundation. Leave one ½ inch (13 mm) gap in the gasket to ensure proper water drainage.

Install the cabinet concrete foundation for the signal service cabinet type SSB as part of the equipment pad concrete foundation using anchor rods, nuts, and washers supplied by the SSB cabinet manufacturer. The anchor rods must project above the concrete foundation to accommodate 1/2 inch (13 mm) thick gasket.

Install the cabinet manufacturer supplied rubber gasket sections between the bottom of each cabinet base and the concrete foundation. The Contractor must leave one 1/2 inch (13 mm) gap in the gasket to ensure proper water drainage.

M. Signal Service Cabinet

Install the signal service cabinet type SSB on the equipment pad concrete foundation as detailed in the Plan to the satisfaction of the Engineer.

N. Compliance with NEC Article 110. 24

1. Available Fault Current Calculations

   (1.1) Calculations for the available fault current at the line side of the meter socket must be provided for each electrical service.

   (1.2) Provide and install labels for the calculation results meeting the following requirements:

      a. Self-adhering label.

b. Machine printed numbers and letters.

c. Suitable for placement in damp locations

d. Paper based labels are not acceptable.

e. Placed in the inside of the service cabinet on the dead front door so it is visible when the dead front door is closed.

f. Containing the following information:

Transformer Size in KVA

Available fault current in amps at the terminations of the utility transformer

Available fault current in amps at the line side of the meter socket.

The date the calculations were made

2. Electric Service Information Form

Fill out the following electric service information form shown below for traffic signal systems.

Provide to the Engineer, prior to final acceptance of the project, four (4) copies of the electric service information form for traffic signal systems and the Engineer will distribute the copies as follows:

1. MnDOT Central Electrical Services Unit (Non-Metro Projects Only), or MnDOT Metro Electrical Services Unit (Metro Projects Only).
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 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.

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Electric Service Information Form For Traffic Signal Systems

Project Number: Contractor:

Date:

MN/DOT Signal System ID	Intersection	Meter Address	Electric Utility Transformer Size In KVA	Length of conductors in feet from transformer connection to meter socket connection.		
				L1 =	L2 =	Neutral =
				L1 =	L2 =	Neutral =
				L1 =	L2 =	Neutral =
				L1 =	L2 =	Neutral =
				L1 =	L2 =	Neutral =
				L1 =	L2 =	Neutral =

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O. Preformed Rigid PVC Conduit Loop Detector Installation

Install loop detectors in rigid PVC conduit in accordance with Standard Plate 8132; as marked by the Engineer; and with the applicable provisions of MnDOT 2565.3G.

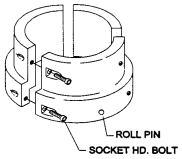
P. Blank

Q. Saw Cut Loop Detector Installation

Saw cut loop detectors in the roadway in accordance with Standard Plate 8130; as marked by the Engineer, and with the applicable provisions of MnDOT 2565.3G.

R. 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.



S. Concrete Walks

Install concrete walks (4") around signal bases in accordance with the applicable provisions of MnDOT 2521; with the Plans; and as directed by the Engineer. The concrete walks may include pedestrian curb ramp(s) if in a curb section. All construction of the concrete walks is considered incidental work.

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T. Pedestrian Curb Ramps

Construct pedestrian curb ramps, at the locations indicated in the Plans, in accordance with MnDOT Standard Plan No. 5 – 297. 250.

U. Accessible Pedestrian Signals (APS) Pushbutton Bases

Install APS pushbutton bases and shafts at locations indicated in the Plans and in accordance with the following:

1. Install 1 inch Rigid PVC Conduit with end bell 2 ± ½ inches above the sidewalk.
2. Support the 1 inch Rigid PVC Conduit with a minimum ½ inch rebar prior to concrete pouring.
   - (2.1) Drive support rebar into the ground below a sufficient depth to adequately support the conduit during concrete pouring operations.
   - (2.2) Remove the support rebar after the concrete has been poured during concrete finishing operations.

After the concrete has cured:

3. Drill four (4) 3/4 inch holes six (6) inches deep into the concrete as detailed in the plans.
4. Install 5/8 inch (UNC) stainless steel threaded rods.
5. Use APS pushbutton base adhesive anchoring systems to secure the stainless steel threaded rods into the drilled holes.
   - (5.1) Follow all manufacturers' installation instructions including cleaning and insertion of the anchor with adhesive.
6. Allow the epoxy adhesive to cure a minimum of 24 hours prior to installing the pedestrian pushbutton pedestal base.
   - (6.1) Follow epoxy manufacturers required cure time prior to installing the pedestrian pushbutton pedestal base.
   - (6.2) Do not exceed manufacturers maximum torque values when tightening nuts holding the pedestal base.
7. Apply anti seize compound to all the exposed threads on the anchor rods, access door cover, set screws, and 4 inch aluminum shaft prior to assembly.

8. Install stainless steel washers and nuts.

9. Plumb pedestal shaft and APS pushbutton base with leveling shims in accordance with Standard Plate 8129.

10. Install a continuous 6 AWG green insulated grounding conductor from the pedestrian pedestal base grounding lug to the nearest hand hole.

(10.1) Exothermic weld 6 AWG green insulated grounding conductor to the ground rod installed in the hand hole.

V. Accessible Pedestrian Push Button Units

Install accessible pedestrian push button units at the locations as indicated on the Plans. Each push button unit contains three (3) custom components:

1. Sign with Braille,
2. Push button with direction arrow
3. Custom voice message.

Pay careful attention to button placement to ensure the button is placed in the correct location. Mount the button facing the pedestrian landing.

Follow the manufactures installation requirements.

Apply an approved electrical insulating coating to the APS wire termination blocks, after wire installation.

MnDOT approved Electrical Insulating Coatings are listed on the MnDOT Approved/Qualified Products Lists WEB site for Signals:

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

Apply a bead of 100% clear silicone sealant around the top of the push button station housing where the push button comes in contact with the pole shaft.

Include the following if the District intends to use pedestial shafts to mount APS buttons with Signal or Pedestrian Heads installed above.
All Red text must be removed from the special provisions prior to the special provisions being submitted for project letting.

W. Accessible Pedestrian Signal (APS) Pushbutton Mounting Spacer

Provide 3 Accessible Pedestrian Signal (APS) Pushbutton Mounting Spacers at each location where an APS button is installed on a pedestal shaft containing signal or pedestrian heads above.

1. Two spacers are used as APS button standoffs and the third shall act as a wire way for the APS button.

X. "As Built Plans"

Provide "as built Plans" that contain any changes in the following:

1. types of foundations
2. pole locations
3. length of mast arms
4. signal bracketing or signal mounts
5. conduit sizes
6. conduit runs
7. number of handholes
8. handhole locations
9. wiring
10. size of detection
11. type of detection
12. cable path
13. other items as required by the Engineer

Indicate any discrepancy or additions between the final plans and how the signal was actually built on the "as built plan".

Provide "as built Plans" in a form that is satisfactory to the Engineer.

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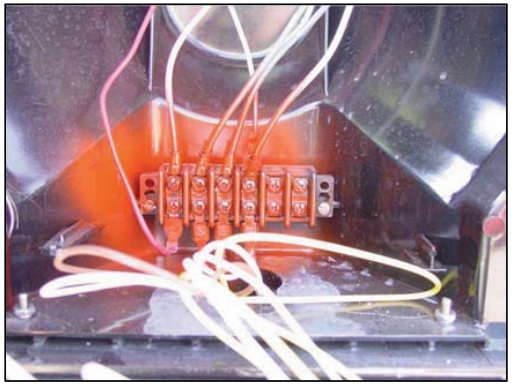
Y. Wiring

Install wiring in accordance with the Plan and MnDOT 2565.3J, and as follows:

1. Vehicle and Pedestrian Signal Heads

   For horizontally mounted terminal blocks, terminate the forks of the spade lugs down on the terminal block for the signal control cable running from the pole base into signal head.



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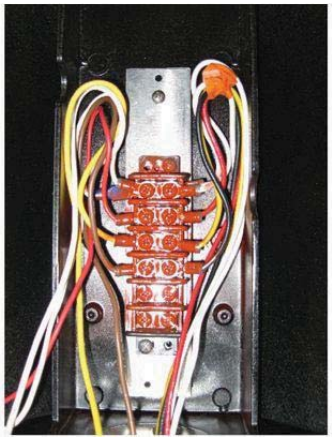
For vertically mounted terminal blocks, terminate the spade lugs for the signal control cable running from the pole base into signal head and loop the conductors to extend up from the terminal block at least 3 inches above the block and then loop the conductors back down to exit the head for termination in the pole base.



After the conductors have been properly terminated, spray the spade lugs and the entire terminal block with an approved pole base terminal block coating. The coating of the terminal block includes spraying the terminal connections and the exposed wire ends where crimped to the spade connector.

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Z. Bonding and Grounding

Provide bonding and grounding in accordance with the provisions of MnDOT2565.3H and as follows:

1. The provisions of MnDOT 2565.3 H, Paragraph 6 are deleted and the following substituted therefore:

   Provide and connect a No.6 stranded, insulated green equipment grounding conductor from the "Equipment Ground Bus" in the traffic signal cabinet or other type cabinet to the ground bus of the service cabinet and to each incoming conduit grounding bushing lug or each No. 6 AWG stranded, insulated green conductor

2. Connection of the daisy chain #6 AWG stranded insulated green grounding conductor that runs from the adjacent signal poles ground rod electrode to the next signal pole's ground rod electrode must be welded to the ground rod electrode with a T type connector utilizing a 3 wiretap connection. A 2 wiretap connection must be utilized at the end of the daisy chain run.

3. Bond of all ground rod electrodes to the #6 AWG stranded, insulated green conductor coming from the traffic signal cabinet and running to the signal pole base using exothermic welding.

4. The exothermic welding is achieved by:

   (4.1) Stripping off enough insulating material from the #6 AWG stranded green insulated grounding wire to ensure the insulation does not burn or melt during the welding process.

   (4.2) Use a manufacturer's specific sized mold for exothermic welding of a #6 AWG stranded copper wire being welded to a non-threaded 5/8 inch copper clad ground rod electrode. Use a T type configuration with a 3 wiretap or 2 wiretap for the mold as specified in the Plans.

   (4.3) Strict adherence to the weld manufactures instructions for material preparation, when welding and testing of the exothermic weld.

5. Bond the #6 AWG stranded, insulated green grounding conductor to the signal pole base 5/16" grounding stud using a NRTL listed re-usable screw type active clamping ground lug with a tang.

AA. Mast Arm Standard Installation

Install mast arm pole standards and transformer bases in accordance with 2565.3P and as follows.

Place an adequate amount of 100% clear silicone sealant between the pole base plate where it meets the transformer base to ensure a moisture proof seal between the pole and the transformer base to the satisfaction of the Engineer.

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(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.

BB. Sign Panel Warning Stickers

Install Department furnished warning stickers on new sign panels in accordance with MnDOT 2564.3H.

Give 30 days advance notice to_____ at ___-___-____ prior to picking up the Department furnished warning stickers.

CC. Removals

When directed by the Engineer, remove and salvage, or dispose of all items of the existing traffic control signal system in accordance with the applicable provisions of MnDOT 2565.3U; 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 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.

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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 signal cabinet, battery backup cabinet and control equipment as specified herein and deliver to the Department at the MnDOT Central Electrical Inventory Center at the location specified elsewhere in these Special Provisions. Notify Mr. Mike Schroeder (612-366-5719) of MnDOT Central Electrical Inventory Center at least three (3) normal working days in advance of the time the Contractor intends to deliver the salvaged materials.

NOTIFY THE ENGINEER IN ADVANCE OF CONTACTING MR. SCHROEDER.

Obtain a salvaged material receipt from the MnDOT 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 signal pedestals as follows:

a) The mast arm pole standards and the traffic signal pedestals (pedestal shafts and pedestal bases) may have been painted with 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 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 signal pedestals as hazardous waste.

c) Provide to the Engineer a completed "Contractor Certification of Disposal" form included elsewhere in these Special Provisions.

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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 work.

SS-2.4 MEASUREMENTS AND PAYMENTS

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. 2565.511 (TRAFFIC CONTROL SIGNAL SYSTEM).

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.

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Contractor Certification of Disposal

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 the MnDOT 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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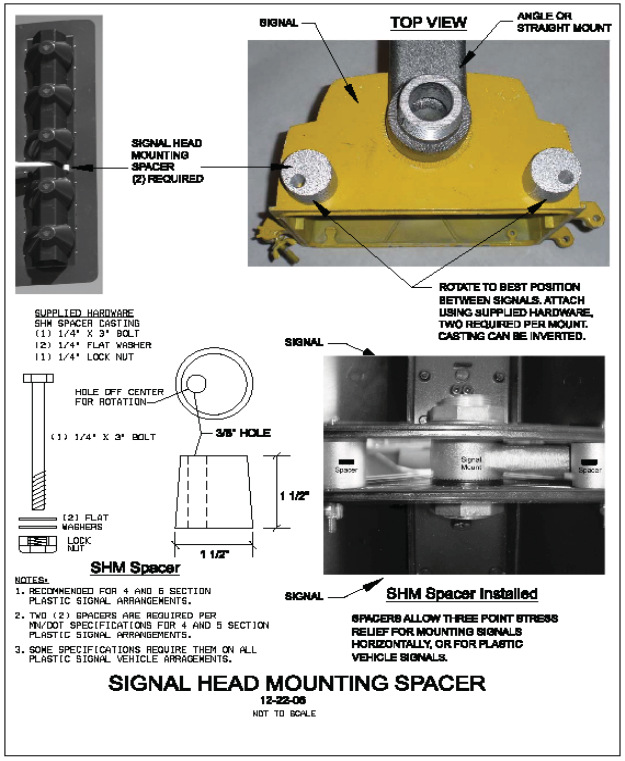


SAMPLE" SIGNAL SYSTEM SPECIAL PROVISIONS (March 03, 2014)

This "sample" set of Signal System Special Provisions will require editing (add, delete, modify, update, etc.) prior to use on a specific project.

SS-3 (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-3.1 GENERAL

A. All applicable provisions of the current edition of the National Electrical Code apply.

B. Provide rack mounted EVP phase selectors (or other approved equal EVP equipment to be installed in the traffic signal cabinet) to be installed in the Department provided cabinet by MnDOT personnel.

Deliver all EVP phase selectors (or other approved equal EVP equipment to be installed in the traffic signal cabinet) to the Department at the MnDOT Central Electrical Services Unit (for approval, and for installation into the Department provided traffic signal cabinet) at least thirty (30) normal working days in advance of when the Department provided traffic signal cabinet is required on the job site.

SS-3.2 MATERIALS

A. EVP Mounting Equipment

Provide EVP mounting equipment in accordance with MnDOT 3814.

B. LED EVP Conformation Indications

MnDOT 3814.2B is deleted and the following substituted therefore:

Use MnDOT approved LED EVP Conformation Indications listed on the MnDOT Approved/Qualified Products List WEB site under Signals:

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

SS-3.3 CONSTRUCTION REQUIREMENTS

A. Emergency Vehicle Preemption (EVP) Installation

Install EVP detectors and EVP indicator lamps at the locations indicated in the Plans in accordance with the provisions of MnDOT 2565.3S.

SAMPLE" SIGNAL SYSTEM SPECIAL PROVISIONS (March 03, 2014)

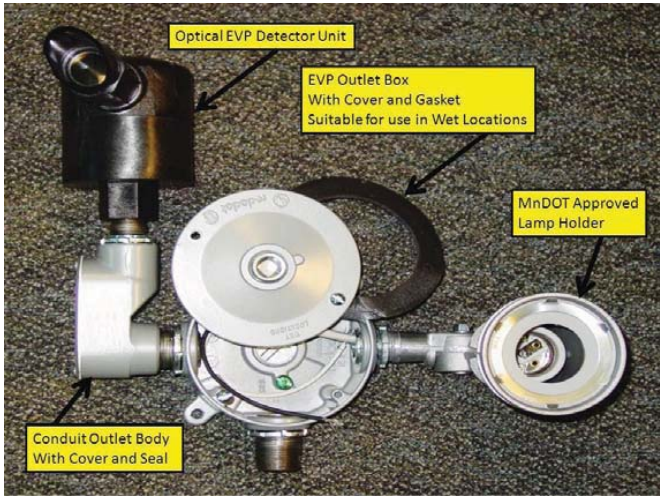
This "sample" set of Signal System Special Provisions will require editing (add, delete, modify, update, etc.) prior to use on a specific project.

B. EVP Conformation Lamp Holder Modification

Disassemble the rubber washer and stainless steel holding clip on the lamp side of the MnDOT approved lamp holder. Remove the fiber washer from behind the rubber washer. Reinstall the rubber washer and stainless steel holding clip.

Install LED EVP conformation indications in each conformation lamp holder. Apply manufacturer supplied dielectric grease to the indication base threads and pin at the time of installation.

The following is a picture of the individual EVP components:



SAMPLE" SIGNAL SYSTEM SPECIAL PROVISIONS (March 03, 2014)

This "sample" set of Signal System Special Provisions will require editing (add, delete, modify, update, etc.) prior to use on a specific project.

SS-3.4 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. 2565.601 [EMERGENCY VEHICLE PREEMPTION (EVP) SYSTEM] at the Contract price per LUMP SUM, which price is compensation in full for all costs incidental thereto.

SS-4 (2565) TRAFFIC CONTROL INTERCONNECTION

This work consists of providing and installing conduit, handholes, interconnect cable, and system loop detectors, for traffic control interconnection on T.H. ___, at the locations indicated in the Plans, all in accordance with the applicable provisions of MnDOT 2565; with the current edition of the National Electrical Code; with the Plans; and as follows:

SS-4.1 GENERAL

A. As part of the traffic control interconnection, the Department will provide the master controller unit and all required master control equipment as part of the traffic signal cabinet at _____ to operate the hardwire 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 hardwire 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 signal cabinet to make the hardwire interconnected coordinated traffic control signal system operational.

SS-4.2 MATERIALS

Interconnect Cable

Provide interconnect cable (___ PAIR # 19 indicated in the Plans) in accordance with MnDOT 3815.2C.6b.

SS-4.3 CONSTRUCTION REQUIREMENTS

Install interconnect cable in accordance with MnDOT 2565.3J2.

SAMPLE" SIGNAL SYSTEM SPECIAL PROVISIONS (March 03, 2014)

This "sample" set of Signal System Special Provisions will require editing (add, delete, modify, update, etc.) prior to use on a specific project.

SS-4.4 MEASUREMENT AND PAYMENT

Providing and installing conduit, handholes, interconnect cable, and system loop detectors for traffic control interconnection on ____, at the locations indicated in 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. 2565.601 (TRAFFIC CONTROL INTERCONNECTION) at the Contract price per LUMP SUM, which price will be compensation in full for all costs incidental thereto.

13.3 NEW REQUIREMENTS FROM AMENDMENT TO MS 216D

Minnesota Department of Transportation

Memo

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Utility Agreements and Permits Unit
Mail Stop 678, 6th Floor
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St. Paul, MN 55155-1899

Office Tel:(651) 296-7018
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February 23, 2006

To: Addressees

From: Marilyn Remer, P.E.
Utility Agreements Engineer

Subject: New requirements from amendment to MS 216D

During the 2004 session, legislators modified Minnesota Statutes Sections 216D.01 (Definitions), 216D.04 (Excavation; land survey), and 216D.05 (Precautions to avoid damage). Except for those made to 216D.05, which describe how to mark utilities in the field, these changes affect some steps in Mn/DOT's utility coordination process. The two most significant changes introduce the utility quality level and the preliminary utility meeting.

MN Statutes Section 216D.01, subdivision 12 defines the utility quality level as follows:

> "Utility quality level" means a professional opinion about the quality and reliability of utility information. There are four levels of utility quality information, ranging from the most precise and reliable, level A, to the least precise and reliable, level D. The utility quality level must be determined in accordance with guidelines established by the Construction Institute of the American Society of Civil Engineers in document CI/ASCE 38-02 entitled "Standard Guidelines for the Collection and Depiction of Existing Subsurface Utility Data."

According to Section 216D.04, subdivision 1a, all plans for projects with excavation must depict the utility quality level of the utility information. Designers must use the following note on all construction plans for projects involving excavation:

> **The subsurface utility information in this plan is utility quality level D. This utility quality level was determined according to the guidelines of CI/ASCE 38-02, entitled "Standard Guidelines for the Collection and depiction of Existing Subsurface Utility Data."**

Note that unless there is proof that the utility information in the plan is more accurate, we will assume that it is utility quality level D. If subsurface utility engineering (SUE) was performed on a project, the designer may use the plans from the SUE provider, making this note unnecessary for any utilities that were covered by SUE.

Due to time constraints, projects that are let in December and projects that are scheduled for a January letting that are beyond receiving comments do not need this note because an addendum to the contract or special provisions will address the utility quality level issue. **The above note or the SUE plans will be required on ALL projects let in February or thereafter.**

Section 216D.04, subdivision 1a goes on to state:

> (c) A person required by this section to show existing underground facilities on its drawings shall conduct one or more preliminary design meetings during the design phase to communicate the project design and coordinate utility relocation. Affected facility operators shall attend these meetings or make other arrangements to provide information.
> (d) A person required by this section to show existing underground facilities on its drawings shall conduct one or more preconstruction meetings to communicate the project design and coordinate utility relocation. Affected facility operators and contractors shall attend these meetings or make other arrangements to provide information.

Mn/DOT is implementing subdivision 1a (c) of this provision by requiring project managers to hold a preliminary design meeting for all projects that involve excavation work. This requirement is effective immediately for all projects on which there is still sufficient time to conduct this meeting.

Mn/DOT has already implemented subdivision 1a (d) of this provision by requiring construction engineers to hold a preconstruction meeting for all projects that involve excavation work.