4-6-1 Signal Infrastructure Design Introduction — April 2025

The design of new or updated traffic signal installations have many interrelated elements. Uniformity in the design of those elements promotes efficient traffic operations and reduces the potential for driver confusion and crashes. Traffic signals must be designed and installed to convey clear and positive guidance to drivers and pedestrians. This subject contains discussions, illustrations, and examples of the design elements that are necessary to achieve this.

In addition to the information contained in this subject there are several standard references that *may* prove valuable to the designer.

4-6-2 Signal Head Layout — August 2025

The layout and display of traffic signal heads are two of the most important elements in the design of a traffic signal installation. Traffic signals must be clearly visible (have good target value) and convey the proper message to the driver and pedestrian. Certain basic principles **shall** be followed at all times when developing the traffic signal head layout. These principles, explained in detail in the WMUTCD, include the following:

1. There **shall** be at least two primary signal faces provided to control the major movement on each approach. The major movement is defined as either the through movement, or the signalized turning movement that is considered as the major movement if a through movement does not exist on an approach. The two primary signal faces **shall** be located on the far side of the intersection, including one on the far left and one on the far right in relation to the approach roadway. A near right signal face *may* also be provided, based on the region traffic signal engineer's discretion or as required per WMUTCD 4D.07. If included, the near right signal face *should* be located approximately at the stopping point.
   a. On multi-lane highways / expressways, newly installed traffic signals **shall** include a signal face for each through lane, or for each lane associated with the major movement, on their respective approaches. These signal faces **shall** be mounted vertically and located approximately over the center of the lane.
2. For non-highway approaches, at least one, preferably both of the far side primary signal faces **shall** be located within a 20-degree cone of vision starting from 10 feet behind the stop line in the center of the approach as defined and illustrated in Figure 4D-4 of the WMUTCD (New installations on multi-lane highway / expressway approaches **shall** have the primary signal faces lined up overhead and approximately centered over each through lane). On all roadway approaches, except where the width of the intersecting street or other conditions make it physically impractical, at least one and preferably both far side primary signals **shall** be located not less than 40 feet or more than 180 feet beyond the stop line (a 50-foot minimum is recommended for post-mounted signals and a 75-foot minimum for overhead mounted signals). A near signal face is required per WMUTCD 4D.07, if the primary signal faces on an approach are located more than 180 feet beyond the stop line. The WMUTCD also states, 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.
3. When a separate left-turn phase is provided, at least two signal faces **shall** be provided to control that movement. Their positions *should* make them readily visible to roadway users making that movement. If two or more left-turn lanes are provided for a separately controlled left-turn phase, then place one signal face per lane.
   a. Supplemental left-turn signal faces *may* be added if engineering judgment dictates their use based on visibility and / or knockdown potential (Consult with the Regional Traffic Signal Engineer).
   b. When right-turn signalization is used for a channelized right-turn lane, at least two signal faces **shall** be provided to control that movement. Their positions *should* make them readily visible to roadway users making that movement. If two or more right-turn lanes are provided for a separately controlled right-turn phase, then place one signal face per lane.

   c. Supplemental right-turn signal faces *may* be added if engineering judgment dictates their use based on visibility and / or knockdown potential (Consult with the Regional Traffic Signal Engineer).

4. The primary signal faces located on the far side of the stem approach to a "T" intersection, *should* be post mounted and one of the signals **shall** be placed directly in line with the center of the approach lane or lanes.
5. State owned traffic signals **shall** utilize 12-inch indications.
6. For new installations or modernization projects, the design goal *should* be to install vertically mounted signal faces in all cases. For signal modification or rehabilitation projects, consult the Regional Traffic Signal Engineer for signal layout questions.
7. Retroreflective backplates *should* be utilized on all vehicular signal faces for added visibility. Consult with the Regional Traffic Signal Engineer and/or Regional Safety Engineer to discuss the backplate material and if the side street backplates *should* be retroreflective.
8. Pedestrian Signal Faces with Countdown Displays **shall** be utilized for all state-owned traffic signals. Pedestrian signal faces **shall** be located as nearly in line with the crosswalk as possible. If the signal pole is located such that the pedestrian signal will be blocked by stopped vehicles or if it is more than 20 feet outside of the crosswalk line extended, then an alternative means of mounting *should* be designed. Pedestrian faces **shall** be mounted at a minimum of 7 feet (to the bottom of the head) above the walking surface on the side of the pole away from conflicting vehicular traffic. Pedestrian faces are typically mounted on the pole alongside the vehicular signal controlling the corresponding through movement.
   a. Pedestrian push buttons, when needed, **shall** be located for convenient use by pedestrians as outlined in WMUTCD 4I.05 and as required by the Americans with Disabilities Act (ADA). In some situations, it *may* be necessary to install a pedestrian push button standard to make the buttons accessible (Refer to SDD 9E7-6). Each push button **shall** be accompanied by a R10-3 series sign explaining its use.
   b. Pedestrian signals *should not* be installed in the medians of divided highways unless vision and timing conditions require it.
9. Permanent traffic signal faces **shall not** be installed on overhead cables or by any other means, which would permit significant movement under windy conditions. Temporary traffic signal faces *may* be installed on overhead cables if construction or maintenance operations would not make post or mast arm mounting feasible. Temporary signal installations **shall** only be used for road construction purposes and *should* be removed upon completion of the project. If a signal will be placed for a long-term duration, a permanent signal *should* be considered.

These guidelines are intended to establish minimum design criteria for traffic signal head layout. Consideration must be given by the signal designer to the unique conditions associated with a specific location and an appropriate design developed in response to these conditions. Specifically, consideration must be given to left-turn movements, right-turn overlaps, pedestrian activity, preemption, and channelization. All these aspects must be evaluated to achieve the best design.

In establishing the traffic signal head layout, attention must be given to signal head displays. Signal head displays will have a direct effect on the location and orientation of the signal heads. These signal head displays must be consistent with the intersection geometrics, vehicular demands, and desired operation. Signal head displays typically consist of three, four, and five section displays. No more than five indications are allowed in each display. Within a signal face, two Circular Red or Red Arrow signal indications **shall not** be displayed immediately adjacent to each other. Reference WMUTCD 4D.08 for Typical Signal Face Arrangements used for Through Movements. Reference WMUTCD 4F.02 through 4F.08 for Typical Signal Face Arrangements used for various types of Left-Turn Movements. Reference WMUTCD Sections 4F.09 through 4F.15 for Typical Signal Face Arrangements used for various types of Right-Turn Movements. Reference WMUTCD 4F.16 for Typical Signal Face Arrangements used for various types of Shared Left-Turn / Right-Turn Lanes and No Through Movement.

In addition to the general design criteria already discussed, further consideration *should* be given to the following items:

- Arrows *should not* be used on near or far indications for through movements. Arrow displays significantly limit the luminance level and conspicuity compared to circular displays.
- Traffic movements that conflict with pedestrian movements **shall** be controlled by circular green or a flashing yellow arrow.

- Consideration *should* be given to using visibility-limiting or optically programmed heads (lenses, louvers, or tunnel visors) under certain conditions. These conditions *may* include two closely spaced intersections where the intent is to limit a driver's ability to see the adjacent intersection display; for exclusive turn movements; or possibly where irregular street alignments necessitates the placement of conflicting signal faces at small angles. In addition, these types of heads *may* prove beneficial where direct sunlight causes drivers problems in determining which indication is illuminated.
- The use of all arrow indications for protected left turn only phasing *should* be used. This eliminates the need for most signing and for programmed heads and their associated maintenance problems and cost.
- The bottom housing of a signal assembly not mounted over a roadway **shall** be at least 8 feet but no more than 15 feet above the sidewalk or, if no sidewalk, above the pavement grade at the center of the highway.
- The lowest part of a signal assembly and all other signal components suspended over a roadway **shall not** be less than 17 feet (20 feet Minimum if located on a Designated Overheight Corridor) nor more than 25.6 feet above the pavement grade of the highest point on the roadway.
- Poles **shall** be located such that all portions of the poles and attached equipment have clearances from overhead utilities in accordance with the requirements of the local utility and the National Electrical Safety Code (NESC).

4-6-3 Signal Poles and Foundations April 2025

In determining the location of traffic signal poles/standards and related foundations, primary consideration must be given to the proper visibility of signal faces. After determining the signal head placement/location for the intersection, the designer **shall** use WMUTCD 4D.10 (Lateral Offset / Clearances) and engineering judgment to determine safe setback distances from the edge of the traveled way for poles and foundations. Poles and standards at the side of a street with curbs must have a horizontal setback clearance of 2 feet minimum, 4' typical from the face of a vertical curb to the edge of the signal face or sign mounted on that pole (whichever extends closest to the curb). Where no curb exists, proper placement of supports is measured from the edge of the pavement. Traffic signal standards **shall not** have a horizontal setback greater than 12 feet from the face of a vertical curb (or edge of pavement if there is no curb). A signal support *should not* obstruct a crosswalk.

Poles **shall** be located such that all portions of the poles and attached equipment have clearances from overhead utilities in accordance with the requirements of the local utility and the National Electrical Safety Code (NESC).

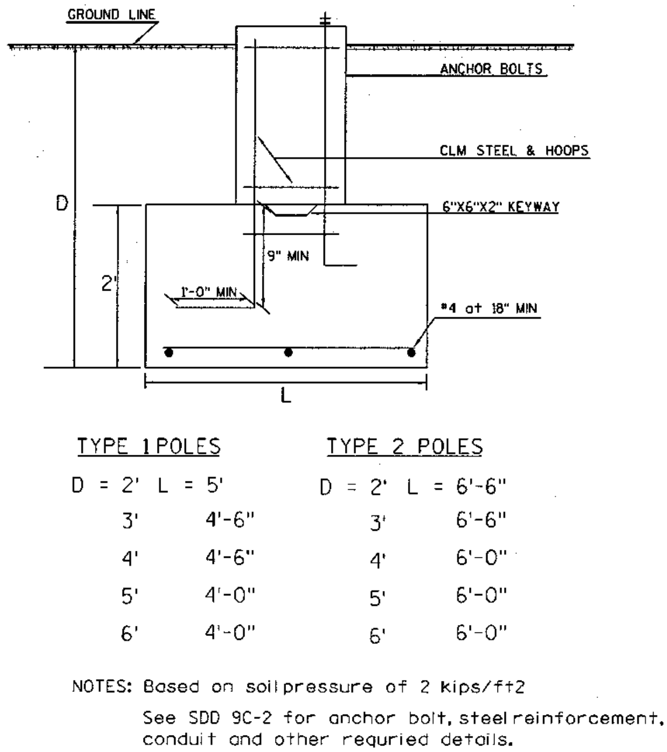
There are nine possible concrete bases available for use. (see FDM Chapter 16, Standard Detail Drawings).

Type 1	For use with Traffic Signal Standards, 15 feet or less.
Type 2	For use with Pole Types 2, 3, and 4
Type 5	For use with Pole Type 5 (Lighting Units 30 Ft)
Type 6	For use with Pole Type 6 (Lighting Units 35-Ft)
Type 7	For use with Pole Type 17 (Lighting Units 40-Ft)
Type 8	For use with Pole Type A (Lighting 46'6") and Type E (Lighting 49')
Type 10	For use with Type 9 and 10 Monotube Poles
Type 10 Special	For use with Type 9 Special and Type 10 Special Monotube Poles
Type 13	For use with Type 12 and 13 Monotube Poles

The current WisDOT signal standard (pedestal) bases and transformer bases (used with Type 1, 2 or 5 / 6 bases) are breakaway. Type 17, A, E, 9, 10, 9 Special, 10 Special, 12 & 13 Poles (used with Type 7, Type 8, Type 10, Type 10 Special and Type 13 bases) are not breakaway and while allowable within the clear zone, *should* be placed as far back from the back of curb as can be reasonable accomplished.

Some areas *may not* allow for the installation of concrete signal bases due to utility conflicts. In these cases, a spread-footing concrete base *may* be required (see Figure 3.1). The Regional Traffic Signal Engineer *should* be contacted to discuss the options when bedrock or utility conflicts obstruct the concrete base depth. Consult with the Bureau of Structures if a spread footing is needed.

Figure 3.1. Alternate Spread Footing Detail (Type 1, 2, 5, or 6 bases)



4-6-4 Conduit Size, Type and Layout — April 2025

CONDUIT SIZING

Conduit sizes of 1, 2 and 3-inch diameter *should* normally be used for traffic signal applications, or for interconnection. Below are the typical sizes of conduit used for various applications (Consult with the individual Regions regarding preferences):

Controller Cabinet to Pull Box:	Varies (see Standard Detail Drawings, and consult with Region Traffic Signal Engineer)
Main Ring Around Intersection (Pull Box to Pull Box):	Two 3" Typical
Pull Box to Signal or Light Base:	2" or 3"
Detector Lead-In:	2"
Loop Detector Conduit:	1"

The minimum conduit size is determined by the number and sizes of cables to be contained in the conduit. For large installations (interchange intersections, major intersections, etc.) the conduit sizing calculations used by WisDOT Regional electrical staff *should* be followed.

CONDUIT LAYOUT

All conduits **shall** be installed in accordance with the Standard Specifications, Wisconsin Administrative Code, and the Wisconsin State Electrical Code.

The conduit layout *should* be designed to minimize conflicts in construction. All conduit runs *should* be as straight as possible to minimize material costs, construction costs and to facilitate the pulling of electrical cable. An attempt **shall** be made to locate equipment such that conflicts between state-owned equipment and existing utilities are avoided.

A conduit **shall** be provided from each signal or light base to the nearest pull box, from pull box to pull box, from pull box to controller cabinet, and from detector to pull box.

Any conduit under a roadway **shall** have a pull box at each end. Spare conduit **shall** be installed as directed by the signal-maintaining authority. In general, conduit runs crossing existing streets, drives, and alleys *should* be directional bored rather than trenched. Conduit **shall** encircle the entire intersection due to the flexibility it will offer for future changes.

For new road construction, trenched conduit *may* be installed around the entire intersection. The conduit layout at the intersection *should* be designed so that the controller is in a quadrant and not on an island or median. This will allow for cabling in two separate directions, which minimizes voltage drop.

CONDUIT CROSSING STRUCTURES

At times, there *may* be a need to install conduit across structures. Typically, this will be the case at diamond interchanges when both ramp terminals are signalized.

When there needs to be a crossing of an existing structure, conduit *may* be installed on the structure itself or *may* be routed below the roadway that the structure crosses. To determine which method is appropriate, the Regional Traffic Signal Engineer and Regional Structures Engineer **shall** be consulted.

When installing conduit on the structure, the conduit *should* run either parallel to or at right angles to the structural girders. A variation of ± 15 degrees *may* be acceptable. A conduit expansion fitting **shall** be installed at each structure joint, hinge, or abutment where longitudinal movement greater than 1/2" *may* occur, or in accordance with manufacturer recommendations.

At locations where conduit runs through a structure, the conduit **shall** be terminated at a pull box. An adjustment *may* be needed to avoid guardrail posts. At the midpoint of the length of the wingwall, run all conduits out of the inside edge of the wingwall (into abutment fill) with a 45-degree bend and continue to a pull box (24” x 42”). The location of the pull box will be dependent on the presence of paved shoulder, sidewalk, terrace, curb, guardrail, drop inlet or surface drain. The intent is to avoid placing the conduit and pull box behind the guardrail. The preferred location will be in the sidewalk (or future sidewalk) or paved shoulder beyond a surface drain or inlet. The conduit *should* then continue from this first pull box to a second pull box located in the grass beyond the guardrail terminal end. Both pull boxes *should* be 24” x 42”.

For exposed locations, such as installations on structural girders, Schedule 80 PVC or RTRC (Reinforced Thermosetting Resin Conduit) **shall** be used. RTRC is generally preferable to PVC due to its durability. The regional traffic section *should* be involved in the selection of the exposed conduit materials.

A third alternative to provide conduit to the opposite side of a bridge, is to install an underground conduit system parallel to the structure and underneath the feature (i.e., roadway, railroad, etc.) being crossed.

USE OF SIGNAL CONDUIT FOR OTHER APPLICATIONS

Electrical wiring in state-owned signal conduit systems for other types of installations that are not associated with signal operation **shall** be avoided for several reasons:

- Reduces capacity of conduit that *may* be required for future signal modifications.
- Wiring used for multiple applications in the conduit *may* violate Electrical Code.
- WisDOT staff does not provide maintenance and locating services for the other electrical and municipal facilities (such as outsourced maintenance and locating of state-owned ITS facilities).
- Changes to wiring that could occupy the same space as signal wiring *may* affect signal operations.

4-6-5 Control Cabinet and Electrical Service — April 2025

SIZES

The standard traffic signal control cabinet in use is approximately 44" x 24” x 55" and is currently specified as a NEMA TS2 Type 1 cabinet. An oversized cabinet approximately 44” x 24” x 65” is available for intersections that require more components than usual (Consult with the Regional Traffic Signal Engineer).

LOCATION

The Regional Traffic Unit will work with the local utility company and signal designer to determine the most appropriate location for the traffic signal control cabinet and electrical service. Control cabinets **shall** be in accordance with, the following considerations:

1. The control cabinet *should not* be vulnerable to traffic. A distance of 20 feet back of curb or 30 feet off the edge of pavement is desirable for offsetting the control cabinet.
2. The control cabinet **shall not** be in a drainage ditch, in an area which could be under water, or where subjected to water from sprinklers. If the only option is to locate in a low area, it is necessary to fill the area in where cabinet is placed.

3. All traffic movements at the intersection *should* be visible from the control cabinet such that when an electrician is troubleshooting the intersection they *may* view the intersection and the interior of the control cabinet simultaneously. The door of the cabinet *should* open away from the curb or traveled way.
4. A maintenance vehicle *should* be able to park close to the cabinet and out of the traveled lanes.
5. The control cabinet **shall not** obstruct sidewalks, multi-use trails, curb ramps, or driveways.
6. The cabinet **shall not** obstruct pedestrian or driver visibility at the intersection.

ELECTRICAL SERVICE

For state-maintained signals, coordinate with the Regional Traffic Signal Engineer regarding how to prepare an application for the electrical service. Some regions *may* prepare the application / wiring affidavit and install the meter pedestal themselves. Other regions *may* set this all up as a contract item for the contractor's coordination / installation. Electrical installations maintained by other jurisdictions often submit their own application for their electrical service (Coordinate with the Local Municipality for clarification). The local utility company installs the electrical service lateral from the power source to the meter socket/pedestal.

The service connection point **shall** be located as close as possible to, or mounted on, the control cabinet. Electrical services *may* come from overhead or underground lines. Underground service feeds are preferred due to their protection from weather and aesthetics compared to overhead lines. The electrical service **shall** be in accordance with WisDOT *Standard Specifications and* local utility requirements.

COMMUNICATIONS

Similar to electrical service, provisions *should* be given for communications service for control cabinet placement options. When deciding if communications are required, consult with the Regional Traffic Signal Engineer. Future operations *should* also be considered when determining whether provisions for communications are applicable.

CONSTRUCTION INSPECTION

Refer to the Construction and Materials Manual, Section 6-55.1.3 Miscellaneous Construction, Electrical Construction for Checklists that pertain to the installation and inspection of these units:

- Figure 1 Conduit
- Figure 2 Lighting
- Figure 3 Traffic Signals
- Figure 4 Loop Detectors

CONTROL CABINET SERVICE PLACEMENT

Since a large part of a signal's design can relate to the location of the signal controller cabinet, this decision *should* be made early in the design. When selecting the location of the controller cabinet at an intersection, there are three primary considerations: available right-of-way, availability of electrical service, and drainage.

There must be an appropriate amount of right-of-way for control cabinet placement. The minimum amount of right-of-way needed to accommodate the signal controller only is approximately 10 x 10-ft. When dealing with very constrained locations, it is important to consider door swing, cabinet access & pull box placement.

Contact the Electrical Utility regarding availability of commercial power at the intersection quadrant being considered. In some cases, it is necessary to provide conduits under roadways, sidewalks, etc. within the design to allow to utility to feed the cabinet location.

Other location considerations include placing the cabinet where it is possible to observe vehicles within the intersection and where it's not likely to be struck by errant vehicles or snow removal operations. Signal controller cabinets *should* be located on higher ground and outside drainage features such as ditches or near spillways.

4-6-6 Battery Backup Systems — April 2025

The recent application of LED traffic signal indications, which consume less power than conventional incandescent lamps, has made battery-powered energy backup systems feasible. However, it is recognized that, because of the cost of such systems, that gradual deployment at strategic signalized intersection locations is appropriate.

Factors that *may* influence the placement of battery backup systems are proximity of other transportation systems, intersection geometry, traffic volumes, corridor (i.e., progressive movement) considerations, or safety considerations.

Signalized intersection locations that meet the criteria below **shall** be equipped with a battery backup system capable of maintaining signal operation, as defined and prioritized below:

1. RR interconnected installations, or
2. Single point urban interchanges, or
3. Diverging Diamond interchanges, or
4. Intersections with triple-left turn lanes

Signalized intersections with battery backup systems are not limited to these intersections. Use engineering judgement to determine other locations to equip signalized intersection with a battery backup system.

POLICY

Location Criteria

Signalized intersection locations that meet the criteria below **shall** be equipped with a battery backup system capable of maintaining signal operation, as defined and prioritized below:

1. RR interconnected installations, or
2. Single point urban interchanges, or
3. Intersections with triple-left turn lanes.

Signalized operations *should not* need to be modified to reduce energy requirements or extend service time. Rather than introducing modified signal operations or displays, signals that function with battery backup systems with low power reserves *may* go into flashing operation.

Intersections and roadway lighting **shall not** be connected to battery backup systems.

SUPPORT

Battery backup systems are expected to maintain safe and efficient traffic operations at critical signalized intersections during power outages. Of concern are intersections that are near railroad grade crossings (for preemption) and geometrically complex intersections.

Besides providing potential benefits to traffic safety and operations, the use of battery backup systems *may* allow increased response times by electrical personnel, which could provide an advantage considering increased signal infrastructure and associated maintenance demands.

4-6-7 Pull Boxes — April 2025

MATERIAL

The old standard pull boxes were constructed from corrugated steel pipe. Because of corrosion associated with certain soil conditions, new side-of-the-roadway installations are now generally constructed from Non-Conductive Materials according to the Standard Specifications. Any pull boxes installed in concrete pavements for loop detectors **shall** be constructed of corrugated steel pipe.

For new construction, side-of-the-roadway pull boxes manufactured with Non-Conductive Materials *should* typically be used. However, like materials (i.e. Steel) *should* still be considered for rehabilitation projects where newly installed or added pull boxes are being intermixed with existing corrugated steel pull boxes (Consult with the Region Traffic Signal Engineer regarding the regional preferences).

SIZES

There are generally nine sizes of steel pull boxes used for traffic signal installations. 12-Inch pull boxes are used in concrete roadways for certain types of loop detector installations. 18-Inch or 24-Inch pull boxes are generally used for Side-Of-The-Roadway installations (Consult with the Region Traffic Signal Engineer regarding Size Preferences for Various Uses)

Standard Size Corrugated Steel Pull Boxes:

12x24-Inch
12x30-Inch
12x36-Inch
18x24-Inch
18x30-Inch
18x36-Inch

24x36-Inch
24x42-Inch
24x48-Inch

Currently, there are two sizes used for Non-Conductive Pull Boxes:
24x36-Inch
24x42-Inch

The engineer *may* use depths up to 42-inches for Non-Conductive and 48-inches for steel. 42-Inch depths are generally considered the minimum depth if running conduit under curb-and-gutter, roadways, and driveways. Refer to the Standard Specifications and Standard Detail Drawings for specific requirements for pull boxes and depth exceptions, or consult with the Region Traffic Signal Engineer for guidance

SPECIAL REQUIREMENTS

Pull boxes **shall not** be installed in asphaltic pavement. 12-Inch corrugated steel pull boxes **shall** be used in concrete pavements for certain types of loop detector installations and **shall** include locking covers.

PLACEMENT

Pull boxes *should* be located at junctions of two or more conduit lines and as near as possible to roadway loop detectors. Pull boxes provide a point from which cables are to be pulled through the conduit or where extra lengths of cables are stored. Pull boxes *should* also be installed:

1. At 200-foot, or less, spacing in conduit runs. Longer runs *may* be used for fiber optic interconnects.
2. At locations where conduits branch.
3. Adjacent to the foundations for signal standards, lighting poles, and controller cabinets.
4. Where loop detector leads are spliced to lead-in cable.

Pull boxes *should not* be in the sidewalk if an alternate location is possible, as they can present a tripping hazard for pedestrians. One possible exception is in the case where conduit is to cross a structure.

4-6-8 Signing and Pavement Marking — April 2025

SIGNS

Supplemental signs recommended for traffic signal operation need not be shown on the signal plan sheet (except for specific signing controlling right turns, i.e. STOP or YIELD). Some of the more common signs include:

SIGNAL AHEAD	W3-3
Pedestrian push button supplemental signs	R10-3 series
LEFT ON GREEN ARROW ONLY	R10-5
LEFT TURN SIGNAL	R10-10
NO TURN ON RED	R10-11b
LEFT TURN YIELD ON FLASHING YELLOW ARROW	R10-50L
RIGHT TURN YIELD ON FLASHING YELLOW ARROW	R10-50R

Foldable stop signs *may* be installed on signal poles for use when state-owned signals are not operating. If folding stop signs are to be used on an approach that has an emergency red flash, they **shall** be placed on the near right and in the median, if a near left signal support exists. Stop signs **shall not** be installed on approaches with an emergency yellow flash.

State of Wisconsin law allows U turns at signalized intersections, unless signs restrict the movement. See TEOpS 2-2-19.1 for additional guidance for placement and use of NO U TURN signs at signalized intersections.

The purpose of left turn arrows on signal heads is to eliminate the need for the use of left turn signs (LEFT ON GREEN ARROW ONLY, LEFT TURN SIGNAL, etc.). The use of these signs *should* be determined on a case-by-case basis. For guidance on the use and placement of LEFT TURN YIELD ON FLASHING YELLOW ARROW signs, refer to TEOpS 2-2-53.

Other traffic control signs (e.g. one-way, no parking, etc.) *should* be installed as needed. These signs **shall** meet the requirements of the WMUTCD and TEOpS policies.

PAVEMENT MARKINGS

Prior to designing the traffic signals on the plan sheet, the pavement markings *should* be located to act as a guide in the location of signal heads, pedestrian heads, and detector loops. All pavement markings **shall** be in conformance with Standard Specifications, TEOpS, and WMUTCD. Any questions regarding pavement markings *should* be directed to the Regional Pavement Marking Engineer.

As stated in 4-5-1, the signal plan sheet **shall** show all crosswalks and stop lines due to their influence on signal and detector placement. The location of handicap ramps *should* also be shown if the crosswalk marking does not adequately show where they are located. The lane lines need to be shown because of their effect on detector and signal head placement and to convey to the review staff the lane designations. Arrows and "ONLY" markings do not need to be placed in all left-turn lanes. Such markings are typically placed at locations where major roads cross, or certain geometric conditions exist. The Regional Pavement Marking Engineer will determine the use of these markings.

4-6-9 Intersection Lighting — April 2025

All state-maintained traffic signals **shall** have lighting installed as part of the signal installation. Local municipality lighting under permit *may* be able to satisfy this requirement. Poles *should* be minimized as much as possible to provide clear sight lines to the signal heads. Therefore, the design *should* combine roadway luminaires with signal poles wherever feasible. When separate street light poles are required, they **shall** be placed to avoid obstructing signal indications.

Historically, it has been standard practice to install at least one luminaire per intersection approach, with additional lighting for high priority area (such as outbound vehicle paths, pedestrian crosswalks, large radius channelized right-turns, and slotted left-turn pockets). For more refined lighting design guidance, reference TEOpS 11-5-1, Signalized Intersection Lighting, and consult with the Regional Lighting Engineer regarding preferences.

Requests for decorative roadway lighting will be handled similar to requests for non-standard WisDOT equipment.

4-6-10 Pedestrian and Bicyclist Crossings — April 2025

Once the determination to install pedestrian signals is made, the next step is to determine where to install the pedestrian signal faces and detection (push buttons) if applicable. The designer **shall** consult the WMUTCD, Section 4E for Pedestrian Control Features and Chapter 9, Traffic Controls for Bicycle Facilities.

Pedestrian push buttons **shall** be shown on the signal plan, mounted approximately perpendicular and in advance of the crossing as required by the WMUTCD.

All pedestrian push buttons **shall** be accessible from the sidewalk to be able to be reached by walkers or people in a wheelchair. This *may* require the installation of a separate pedestrian pushbutton standard. Attempts to locate the pedestrian push buttons as shown in the WMUTCD and per ADA requirements **shall** be made.

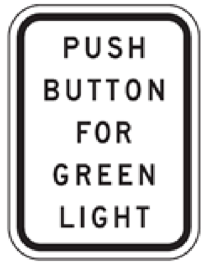
The R10-3E, 3H, 3I, and 3J series pedestrian signs **shall** be mounted on the same poles or standards as the pedestrian push buttons for pedestrian signals with countdown displays. The countdown display style of pedestrian signals **shall** be used on all state-owned traffic signals.

All pedestrian signal faces *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. Sometimes this can be accomplished by attaching the pedestrian signal faces to traffic signal poles or standards. But, to meet the above requirement, a 10-foot pedestrian signal standard *may* need to be installed with just the pedestrian signal face and push button. If the pedestrian signal face can be installed on the traffic signal pole or standard, a 3.5-foot standard *may* still need to be used for a pedestrian push button to comply with the accessible requirements.

The pedestrian phasing *should* be shown adjacent the vehicular phasing on the sequence of operations sheet, shown by a double half arrow on the appropriate side of the vehicular phase arrow.

To accommodate bicyclists who want to cross a highway, a push button accessible to the bicyclist and sign stating, “Push Button for Green Light” (R10-3) as shown in Figure 10.1, *may* be installed. In this case, pedestrian signal faces are not installed; activation of the push button will call and time the pedestrian phase intervals or the bike minimum green interval.

Figure 10.1. R10-3 Sign for Bicyclist



ANIMATED EYES SYMBOL

Reference is made to the WMUTCD 4I.02.

The animated eyes symbol is a dynamic display that supplements standard pedestrian signal indications within the same section. This symbol consists of illuminated eyes that scan from side to side and is meant to prompt pedestrians to be aware of approaching vehicles.

POLICY

Pedestrian signal heads **shall** not incorporate the animated eyes symbol at state-owned signal installations.

SUPPORT

WisDOT supports the use of technologies that address a distinct need related to highway safety & traffic operations. Animated eyes are expected to have a limited effect on improving intersection safety but would require an increase in capital, operations, and maintenance costs. Benefits are not expected to outweigh additional resource expenditures.

IN-ROADWAY WARNING LIGHTS AT PEDESTRIAN CROSSINGS

Reference is made to the MUTCD Chapter 4U.

In-roadway warning lights (IRWLs) are special types of highway traffic control devices installed in the roadway pavement to warn road users that they are approaching a condition on or adjacent to the roadway that *may* not be clear and might require the road users to slow down and/or yield.

IRWLs are actuated devices with flashing indications that provide real-time warning of a specific condition. In-pavement lights that supplement pavement markings by operating in a steady burn state **shall** also require WisDOT approval but are not the focus of this policy.

On the STH system in Wisconsin, IRWLs are limited to situations warning of: marked school crosswalks, marked mid-block crosswalks, marked crosswalks on uncontrolled approaches, and other roadway situations involving pedestrian crossings that are not associated with other types of traffic control.

POLICY

IRWLs, as defined herein, *may* be used on the Wisconsin STH system provided the local jurisdiction:

1. Applies for a permit
2. Agrees to fund the installation, operation, and maintenance of the device
3. Agrees to be responsible for any corresponding damage to the roadway or damage to highway maintenance equipment, and
4. Properly cites appropriate locations based on the conditions of this policy.

The municipality *should* understand that the permit *may* be revoked, especially in the event of safety or operational issues. In such a situation, the original costs and costs to restore the pavement are the obligation of the permit holder.

When allowed by permit, IRWLs **shall** be installed perpendicular to the direction of travel on the roadway and used to supplement crosswalk markings. IRWLs placed along the centerline of a highway, parallel to the direction of travel, **shall not** be used. IRWLs **shall not** be allowed on freeways or expressways.

Prior to the use of IRWLs, adequate trail of standard remedial measures **shall** be used to warn motorists of pedestrian crossings. IRWLs will be used only to supplement typical warning devices such as signs, markings, and crossing guards. Other strategies, such as providing a median refuge roadway lighting in advance of the crossing, or enforcement campaigns, are more universally recognizable methods of warning motorists of these conditions and *should* also be implemented when practicable.

Location Criteria

It is recognized that the use of IRWLs *may* affect STH traffic operations by increasing delay and reducing mobility, especially if used near existing signalized or stop-controlled intersections. The following criteria **shall** be met:

1. Location is an uncontrolled pedestrian crossing.
2. Location is an established school route, accommodates a minimum pedestrian volume of 100 pedestrians/day, or location has experienced pedestrian crashes in the past 3 years.
3. Subject crossing is in municipal (non-rural) limits.
4. There exists a minimum of 300 feet between the subject crossing and the nearest uncontrolled pedestrian crossing, or intersection traffic control device on the STH.
5. There exists a minimum of 1200 feet between the subject crossing and the nearest uncontrolled pedestrian crossing supplemented with in-roadway warning lighting unless exceptional conditions exist.
6. Roadway has a maximum of four travel lanes with a maximum single-stage crossing distance of 50 feet.
7. Approach speed is posted at less than 50 mph.
8. Adequate stopping sight distance exists based on the following approach speeds:
    a. 15 or 25 mph = 200 ft
    b. 30 mph = 250 ft
    c. 35 mph = 300 ft
    d. 40 mph = 400 ft
    e. 45 mph = 500 ft

Design Requirements

In the interest of uniformity, reliability, and consideration for other highway users, the following minimum design requirements for IRWLs **shall** be met:

1. Number/positioning of lights:
    a. For two-lane undivided roadways: 5 IRWLs per direction
    b. For four-lane undivided roadways: 7 IRWLs per direction
    c. For four-lane divided roadways: 5 IRWLs per direction.
2. IRWLs **shall** be actuated and **shall not** flash continuously.
3. If pedestrian push buttons are used to actuate the IRWLs, a PUSH BUTTON TO TURN ON WARNING LIGHTS (R10-25) sign **shall** be mounted adjacent to or integral with each pedestrian push button.
4. For four-lane divided roadways with median widths equal to or exceeding 6 feet, pedestrian actuation in the median **shall** be provided to allow for a two-stage crossing of the roadway.
5. Lights **shall** be evenly spaced across the entire traveled way. Lights *should* be positioned outside of vehicle wheel paths and *should* also consider bicyclist routes adjacent the traveled way. Lights placed near the centerline of the roadway *should* be offset slightly to minimize interference with pavement marking operations.
6. Electrical wire **shall** be cast in a minimum of 8-inch concrete pavement. If IRWLs are being installed with an improvement project that requires a pavement section greater than 8 inches, then the pavement at the crossing *should* be made to match that of the adjacent roadway. Pavement reinforcement *may* not be required, but this decision will reside with the regional pavement design unit. Doweling to adjacent concrete pavement will also be required at the direction of the regional pavement engineer. A minimum 2 feet of clearance to the edge of the concrete **shall** be maintained. Pavement structure **shall** be installed according to WisDOT Standard Specifications. Installation in existing pavement by sawing or coring is not permissible. Minimal width of the concrete, measured longitudinally in the direction of traffic, **shall** be 12 feet.

7. Roadway profile **shall** be appropriately maintained by milling or wedging the approach to the crossing, as required.
8. IRWLs **shall** flash for the entire calculated pedestrian clearance time. Pedestrian clearance *should* be calculated based on a 3.5 ft/sec walking speed. Locations frequented by children and elderly users *may* have a pedestrian clearance based on a slower walking speed. A brief time extension of 3 to 7 seconds *may* be added to allow for vehicle/pedestrian response and separation.
9. Features meant to accommodate impaired pedestrians such as actuator buttons with locator tones, supplemental braille signing, etc., *should* be considered at individual locations on a case-by-case basis. If used, these devices **shall** be furnished and maintained by the municipality that requests the IRWLs.
10. Other design criteria **shall** conform to the manufacturer's recommendations.

SUPPORT

There are several general points of concern regarding the use of these devices:

1. IRWLs do not ensure that motorists will appropriately yield the right of way to pedestrians in the crossing.
2. A public awareness and education campaign *may* be required to educate the public prior to operating IRWLs.
3. IRWLs *may* cause rear-end collisions similar to a signal installation.
4. Placement of IRWLs between coordinated traffic control signals *may* cause progression problems.
5. Any improperly installed electrical equipment *may* pose a hazard to the public.
6. In Wisconsin, IRWLs *may* be susceptible to premature failure due to moisture buildup and/or snow removal operations.
7. The type of actuation used for IRWLs needs to be considered. Active detection (i.e. pushbutton) *may* create a false sense of security for pedestrians who are not familiar with the use of such devices or the rules of the road. Because of these factors, passive detection (i.e. infrared) is considered more appropriate for these types of applications, especially in crosswalks associated with school zones. In either case, an informational plaque *should* be used to briefly describe proper crossing behavior while using IRWLs. These are similar to informational plaques used at signalized pedestrian crossings (R10 series).
8. In IRWLs will be placed outside of existing connecting highway limits within a municipality, consideration *should* be given to extend those limits to include the installation location.

4-6-11 Emergency Vehicle Preemption (EVP) and Traffic Signal Priority (TSP) Detection — April 2025

Follow the manufacturer's specification for correct mounting height of emergency vehicle detectors. Line of sight criteria **shall** be considered when showing EVP and TSP detectors on signal plans for certain kinds of systems. The newer GPS based systems do not rely on line-of-site. Check with the vendor supplying the equipment and local municipality requesting the system regarding system requirements.

4-6-12 Monotube Signal Arms and Pole Structures — April 2025

The following is a set of guidelines related to the use and placement of monotube signal arm assemblies for traffic signals. It is to be used by Regional Traffic Signal Engineers and consultants for the design (or design review) of a signalized intersection.

1. Monotube arm assemblies **shall** be used on any approach with two or more through lanes for modernization projects (State owned signals only).
2. Monotube arm assemblies *should* be used on any approach with two or more through lanes for resurfacing, pavement replacement, and reconditioning projects (when feasible based on available right-of-way and other constraints) (State owned signals only).
3. Signal heads *should* be mounted in such a way that they are centered over their respective receiving lane. Two 3-section signal heads *may* be vertically mounted on a trombone arm if the far head placement does not exceed 22' from the pole. Engineering judgment *should* be used to determine the appropriate location

for each head when the roadway is skewed, or other unusual geometrics cause a shift between the approach lanes and receiving lanes.

4. Poles with monotube arm assemblies *may* be installed in “pork chop” divider safety islands and in median islands. A raised median is defined as having a minimum width of 6’ face-to-face (although 8’ is desirable).
5. Poles with monotube arm assemblies are not required to be shielded; however, engineering judgment *should* be used to determine a reasonable offset from any adjacent travel lanes since the bases are non-breakaway.
6. Reverse mounted monotube arm assemblies *may* be used.
7. Ideal pole placement *may not* facilitate proper ADA push button placement, therefore additional poles for pedestrian push buttons *may* be required.
8. Monotube arm assemblies with a signal head positioned for each lane *may* be utilized for single or multiple left turn lane designs however are not required.
9. A luminaire can be mounted above the monotube arm, 180-degrees from the monotube arm, or in both locations. Contact the Regional Signal Engineer for permission to add a clamp-on camera to the luminaire arm.
10. For typical design information, see Standard Detail Drawings 9E8.
11. The concrete base **shall** be further extended above ground when the ground elevation at the base is lower than the high point of roadway elevation. See Standard Detail Drawing 9C13 for construction information.
12. Each monotube arm assembly and pole structure **shall** be assigned a structure number by the Region. This number **shall** appear on the traffic signal plans and will be identified in the field on each pole. Regional electricians **shall** work directly with their Regional Signing Coordinator to place an order for each identification plaque. Installation of the plaques **shall** conform to the guidance in Standard Detail Drawing 12A4.
13. The Designer **shall** be responsible for calculating the overturning and twisting factors associated with each monotube arm assembly and pole structure layout to ensure that they have not exceeded the maximum loading. The table of maximum values for these factors (and an example calculation) can be found in Figure 12.1. The designer’s calculations *should* be made available to the Regional Traffic Signal Engineer or the Statewide Traffic Signal Engineer upon request. A few items to note when using these equations:
    - <u>No</u> additional calculations are required to account for the luminaire and luminaire arm on the Type 10 & Type 13 poles.
    - Signs and signals that are mounted perpendicular to the face of the monotube arm do <u>not</u> need to be included in the calculations.
    - Effects of push buttons are considered negligible and therefore do <u>not</u> need to be included in the calculation.
    - Square footage information for standard signal equipment is as follows:
        - 5 section signal head – 13.33 sq. ft.
        - 4 section signal head – 11.00 sq. ft.
        - 3 section signal head – 8.67 sq. ft.
        - 1 section pedestrian head – 2.0 sq. ft.

Figure 12.1. How to check loading on a monotube signal/sign structure

This example shows how to check the ability of a monotube traffic signal structure to carry a proposed loading. The number of traffic signal attachments, signs, and their dimensions are for illustrative purposes only. The calculations for any given installation will vary by the specific number of traffic signal attachments, signs, and their dimensions and positioning for that specific installation.

Given: Type 12 pole, 50' arm, loading with signals and signs, positioned and dimensioned as shown in illustration.

Determine: Adequacy of Type 12 pole with 50' arm to carry proposed attachments

Calculate overturning and twisting factors (mv) & (mh):

mv = sum (each attachment area X distance from arm attachment point to the bottom of the upright)

mh = sum (each attachment area X distance from the center of each attachment to the center line of the upright)

area of 5-head signal on arm = 2' X 6.67' = 13.33 sq.ft.

area of directional sign on arm = 2' X 2.50' = 5 sq.ft.

area of <u>each</u> 3-head signal on arm = 2' X 4.33' = 8.67 sq.ft. <u>each</u>

area of sign on pole = 3' X 4' = 12 sq.ft.

mv = [(13.33 sq.ft. + 5 sq.ft. + 8.67 sq.ft. + 8.67 sq.ft.) X (19 ft. nominal)] + [12 sq.ft. X 10 ft.] = 797.73 ft^3

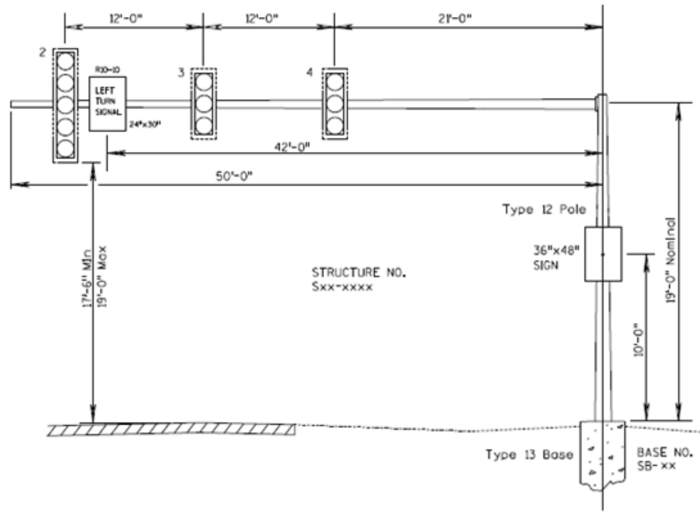
mh = (13.33 sq.ft. X 45 ft.) + (5 sq.ft. X 42 ft.) + (8.67 sq.ft. X 33 ft.) + (8.67 sq.ft. X 21 ft.) + (12 sq.ft. X 0 ft.) = 1278.0 ft^3

<u>Enter table for checking loading using the row for a 50 ft. arm length:</u>

Overturning factor = MV = 1733 ft^3 maximum

Twisting factor = MH = 2151 ft^3 maximum

The proposed loading of signal and sign attachments on the Type 12 pole with a 50 ft. arm is acceptable since mv = 798 ft^3 is less than MV = 1733 ft^3 and mh = 1278 ft^3 is less than MH = 2151 ft^3.



<u>Table for checking loading on a monotube traffic signal structure</u>

Arm length (ft)	MV (maximum) (ft^3)	MH (maximum) (ft^3)
15	834	295
20	1007	416
25	1007	594
30	1007	771
35	1560	1168
40	1560	1477
45	1733	1792
50	1733	2151
55	1733	2510