These design current practices are to be applied in conjunction with the most recent version of the WSDOT Design Manual, WSDOT Standard Specifications, WSDOT Traffic Manual and the Manual for Uniform Traffic Control Devices (MUTCD).

TRAFFIC SIGNAL SYSTEM DESIGN

Traffic Signal Controller and Cabinet

The current design standard for WSDOT traffic signal systems is a type 2070 controller, with Nextphase software, installed in a Type 332D double wide controller cabinet. Coordinate with the WSDOT Signal Operations Engineer to determine the need for supplemental controller modules and control equipment.

As a design standard the Traffic Signal controller cabinet shall be a type 332D double wide cabinet. As an alternative, a Type 332 (standard width) controller cabinet may be considered in locations where little or no communication equipment is anticipated and where design constraints such as limited ground space or right of way prevent the installation of a Type 332D double wide cabinet. The installation of a Type 332 cabinet must be approved by the Regional Traffic Engineer.

The right side of the Type 332D cabinet, when facing the front, shall contain the traffic signal control equipment. The left side of the cabinet, when facing the front, shall be reserved for communication and ITS control equipment.

The controller cabinet shall include a Generator Transfer Switch accessible from the outside of the cabinet. The Generator Transfer Switch shall be installed on the same side of the cabinet as the police panel.

The controller cabinet shall include all equipment required to operate all potential signal, pedestrian and emergency preemption phases. The type 332D cabinet shall also include an auxiliary rack for additional future load switches. Consult with the WSDOT signal maintenance personnel to determine the need for an auxiliary rack in a Type 332 cabinet. Do not install a display panel in the controller cabinet.

Controller cabinets installed on a slope steeper than 3:1 shall include a 4 foot high chain link safety fence around the perimeter of the cabinet foundation pad with slope protection to prevent dirt and debris from sloughing onto the pad. Provide an access point or gate through the fence to the cabinet.
The signal controller cabinet shall be installed with the front doors of the cabinet opening away from the intersection. Consult with the WSDOT Signal Operations Engineer to determine the optimum location/orientation of the controller cabinet.

Avoid placing the controller at locations where it might block the view of right-turn on red vehicles. Do not locate a controller in an area prone to flooding. Place the controller in a location where the risk of it being struck by errant vehicles is minimized.

Coordinate with the WSDOT Signal Operations Engineer to determine the need for traffic signal system interconnect equipment. It may be required to extend interconnect to a mainline coordination system or corridor signal control system.

All Traffic Signal equipment, including controller cabinet, signal standards, junction boxes and conduit shall be located inside of Wsdot right-of-way.

**Traffic Signal Phasing**

Always consult the WSDOT Signal Operations Engineer for additional input and recommendations regarding phasing and signal operations. When the traffic signal is owned or operated by a Local Agency (city or county), the signal phasing and other operational design considerations should be coordinated with that agency’s representative.

Split phasing may be required due to shared through/left lanes, turning path conflicts or limited sight distance. This is an inefficient way to operate a signal and should be avoided where possible.

Phase 2 is assigned to the northbound movement when the mainline runs north and south or to the eastbound movement when the mainline runs east and west. Typically when a state highway intersects with a non state highway, the state highway is considered the mainline.

**Left Turn and Right Turn Signal Phases:**

The number of signal phases at a signalized intersection should be kept to a minimum by only including protected left turn signal phases when the need is established per the Region’s Left-Turn Phasing Criteria.
Overlap signal displays for a right turn pocket are not considered an additional signal phase and should be installed whenever they can make a improvement to right turn traffic flow and not conflict with another vehicle or pedestrian signal phase.

Where opposing left turn movements occur at an intersection, both of the opposing approaches shall have the same type of left turn phasing whether protected-permissive, protected, or permitted. When opposing approaches are not operated with the same type of left turn phasing, a potentially dangerous condition known as the yellow trap or fools yellow can occur under certain operational conditions.

**Left Turn Phasing Criteria:**

When evaluating an intersection for protected, permissive or protected-permissive left turn operation, field observation and application of sound Engineering judgment are necessary.

Permissive phasing shall be the first consideration for left turn phasing. A protected left turn phase shall be utilized when conditions, as indicated in the WSDOT Design Manual, require a protected left turn phase or prohibit the use of a protected/permissive left turn phase.

Other factors to take into consideration:

- If confusion would result due to the character of the channelization or geometry, protected only phasing should be considered.
- If there are numerous access points adjacent to an intersection where cars may enter unexpectedly, protected only phasing should be considered.
- If motorists tend to use the opposite shoulder as a driving lane for right turns, protected only phasing should be considered.
- Consider approach grades when evaluating an intersection for protected only operation. Vehicles making the left turn movement during a permissive phase may stall out or have difficulty clearing the intersection due to the grade, especially when the roadway is wet or covered with ice.

If permissive phasing has been determined to be the appropriate left turn phasing, consider adding a protected phase to make the left turn a protected-permissive phase. Consider left turn protected-permissive phasing under the following circumstances:
• When left turn protected-permissive phasing would enhance signal operation efficiency

• When gaps in opposing through traffic are not sufficient to clear the left turn queue in a timely manner

• When the left turn queue regularly exceeds the left turn pocket length and vehicles spill into the adjacent through lane.

• When the multiplying of peak hour left turn volumes times peak hour opposing through volumes exceeds a value of 60,000.

**Flashing Yellow Arrow (FYA) Left Turn Signal Display:**

The *Flashing Yellow Arrow* signal display for left turn protected-permissive phasing may be considered as an alternative to the protected-permissive phasing that typically uses the five section doghouse signal display. The FYA configuration allows the protected phase or the permissive phase to be disabled during optimum times of operation. The FYA configuration should only be considered at locations that meet the criteria for protected-permissive phasing. **Installation of the Flasing Yellow Arrow configuration must be approved by the Regional Traffic Design Engineer.**

**Signal Standards and Foundations**

Signal installations, which are designed to be in place for five years or longer are considered permanent signals. Type II or Type III steel signal standards shall be used for all permanent signal installations.

Signal Bridge installations may be considered if the intersection configuration does not allow for a more conventional Type II or Type III signal pole design. Signal bridges shall be the monotube type. Truss type signal bridges will not be allowed. Signal Bridge installations must be approved by the regional Traffic Design Engineer. Signal Bridge designs must be approved by the WSDOT HQ Bridge and Structures office.
**Signal Standard Placement**

During field investigation for signal standard placement, a field survey is required to locate all underground and overhead utilities. Any underground utility found to be within 10 feet of the proposed signal standard foundation requires pot holing to accurately determine the exact location and depth of the utility.

**Mast Arm Signal Standard**

Mast arms on Type II and Type III signal standards shall be designed with a mast arm attachment angle (E1) value of zero. Design double mast arm signal poles with one mast arm attachment angle (E1) of zero degrees. Rotate the signal standard shaft as required to achieve the desired pole orientation angle (POA) of the signal standard to the roadway.

The total design wind load value used to design Type II and Type III signal poles and foundations shall be determined by adding a future wind load value of 500 cubic feet to the calculated proposed wind load. Reduce the future wind load value accordingly if the total design wind load exceeds 2900 cubic feet. Do not exceed 2900 cubic feet of design wind load.

Install tenons on signal pole mast arms for future signal display configurations. When present or future roadway channelization plans include left turn or right turn lanes, install tenons on the mast arms that would accommodate future protected or protected/permissive phasing.

Design Signal Standard mast arms with an additional 4 feet of length beyond the required length for the proposed sign, signal head and future tenon installations.

Document on the Signal Standard Detail sheet, for each pole, the elevation at the top of the foundation, the lateral bearing pressure of the soil at each foundation location and the total length of the mast arm (which would include the 4 feet beyond the last attachment point). The elevation requirement can be dismissed if the top of the signal pole foundation is installed level with the top of adjacent sidewalk and this is documented on the Signal Standard Detail sheet.
Clearance to Power Lines

A minimum of ten feet of clearance shall be maintained between any Wsdot signal equipment or structure and overhead utility power lines, including the neutral line. Larger clearance is required for power lines exceeding 50KVA.

Signal Standard Foundation

All signal pole foundation design work requires a soil investigation. Existing bore information may be available from the Regional Materials Lab.

A tag indicating the signal pole foundation depth and width or diameter shall be permanently attached to the top of the signal pole foundation.

Signal standard foundations installed in or adjacent to sidewalks or walkways shall be installed with the top of the foundation level with the top of sidewalk.

Existing foundations scheduled for removal shall be removed completely and the void backfilled.

Vehicle Signal Displays

All traffic signal heads shall be 12” in size with an LED light source.

When modifying an existing traffic signal system, replace all existing incandescent signal heads with LED signal heads.

Use directional, louvered or extended visors for appropriate signal displays at a skewed intersection. The intent is to shield visibility of signal displays from drivers on an approach for which the displays are not intended. When directional visors are installed for displays supported on a span wire, a tether shall be used to stabilize and maintain proper orientation of the directional visors. Programmable 3M vehicle signal displays shall not be used unless approved by the Region Traffic Design Engineer.

Install back plates with all vehicle signal displays. When modifying an existing traffic signal system, install back plates on all new and existing vehicle signal heads associated with the traffic signal system. Install 1” wide yellow reflective tape around the perimeter of all new and existing vehicle signal display back plates.
Doghouse Displays

Use a five section “doghouse” display for protected-permissive left turn phasing and right turn overlap operations. The doghouse display provides a configuration of yellow and green balls for the through movement and yellow and green arrows for the turning movement while sharing a common red ball. The five section doghouse displays shall be centered on the gore line between the respective left turn or right turn lane and the adjacent through lane.

Follow Through Signal Display

When protected left turn signal displays are installed, install a follow through protected left turn signal display on the far side of the intersection. The purpose of the follow through display is to give a left turning vehicle a continuous view of the left turn signal indication as they travel through the intersection. The follow through signal display should be identical in configuration to the protected left turn signal display over the left turn lane. The follow through signal display can be shaft mounted on a Type II or Type III signal standard or installed on a Type PS pole.

Flashing Yellow Arrow Signal Display

The Flashing Yellow Arrow signal display is a four section display consisting of a red left arrow, solid yellow left arrow, flashing yellow left arrow and a green left arrow configured vertically. The 4-section Flashing Yellow Arrow signal display should be installed four feet into the left turn lane as measured from the gore line between the left turn lane and the adjacent through lane.

Signal Display Clearance

Signal display clearance to the roadway shall be calculated for each signal head located over the traveled way or shoulder. The minimum and the maximum clearance should be within the values as defined in the most current WSDOT Design Manual (see design manual exhibit 1330-9). As a design convention, the vertical measured clearance should be designed to a point as close to the maximum clearance value as reasonably possible.
Signal Display Mounting Brackets

Vehicle signal displays installed on mast arms shall use the Type M mounting bracket. Type L or LE brackets may be considered only as a method of last resort when modifying an existing signal system. Astro brackets are not allowed for permanent installations.

Type M mounting brackets shall be attached to the mast arm with welded tenons. All tenons on new signal pole mast arms shall be factory installed. Field welded tenons will only be allowed when adding or relocating signal heads on existing mast arms.

Vehicle signal displays installed on span wire shall utilize Type P mounting brackets.

Pedestrian Signal Displays

At signalized intersections, provide pedestrian signals for all marked crosswalks. At locations, such as right turn slip ramps behind an island, do not provide a pedestrian signal if the pedestrian crossing is not marked and the ramp is not controlled by a signal.

Pedestrian Signals shall be have a countdown function and LED displays.

When installing new pedestrian signal displays or relocating existing displays, the pedestrian signal displays shall be located between two lines intersecting with the center of the crosswalk at a point 10 feet from the end of crosswalk (closest to the displays), one making an angle of 20 degrees to the right of the center of the crosswalk extended and the other making an angle of 20 degrees to the left of the center of the crosswalk extended.

The pedestrian signal display should be located no more than 12 feet from the traffic curb edge of the crosswalk landing.

Pedestrian Detection System

The current standard for pushbuttons is a pedestrian pushbutton assembly that meets accessible pedestrian signal (APS) requirements per the most current version of the MUTCD. The pushbutton assembly shall be a 4-wire type of system with individual controller units located in the associated pedestrian signal display.
housing. Each pushbutton assembly should be forest green in color and include a 9”x12” sign with the crossing street name identified in Braille on the sign.

All APS pedestrian pushbutton assemblies at a signalized intersection shall be the same model from the same manufacturer.

As a design standard, pedestrian pushbuttons shall be installed on a Type PPB post, with one pushbutton per post. If design constraints make this impractical, other consideration can include mounting the pushbuttons on Type PS, Type II or Type III signal poles. Locating two pushbuttons on a single pole or post may be considered only after all other options have been eliminated. Pushbutton assemblies shall be separated by a minimum of 10 feet (horizontal) unless prevented by overriding design constraints. When APS pushbuttons are installed less than 10 feet apart, they shall include a talk to walk message in accordance with the most current MUTCD manual.

Within the recommended area for pushbutton locations as indicated in the 2009 MUTCD, pushbuttons should be located to the back of the sidewalk area whenever possible. The pushbutton assembly should be located such that a person in a wheelchair activating the pushbutton would be able to stop on a flat, level surface, with no more than a 2% slope. Avoid installing pushbuttons where a person in a wheelchair would stop on a slope transition between a landing pad and a ramp.

Pushbutton assemblies shall be installed with the face of the pushbutton assembly facing the intersection and parallel with the associated crosswalk.

Install pedestrian signal pushbutton assemblies 42” above the sidewalk or walkway. If design constraints or other factors prevent the installation height of 42”, install the pushbutton between 36”(min) and 48”(max).

As a design standard, install pushbuttons with a maximum horizontal reach (from a level walkway surface) of 10”. If design constraints or other factors prevent the 10” reach requirement from being achieved, the horizontal reach can be extended to a maximum of 18”.

When the pushbutton post or pole is installed at the back of sidewalk, the post or pole foundation should be incorporated into the wall, barrier or curb as much as possible in order to minimize the offset distance from the walkway to the center of the pushbutton assembly.

When existing pedestrian pushbuttons assemblies are replaced with APS pushbutton assemblies, all pushbuttons assemblies associated with the traffic signal shall be replaced with APS pushbuttons of the same make and model.
Vehicle Detection System

As a design standard, install induction loops as the primary method of providing vehicle detection at signalized intersections and approaches.

Install stop line detection in all lanes of a signalized intersection. Install dilemma zone or queue loop detection in all lane approaches to the intersection. Dilemma zone detection shall be provided in through lanes, where the 85th percentile speed is 35 mph or greater.

Dilemma zone detection is not provided in turn lanes, on the stem of T intersections, or at off ramp terminals with little or no traffic traveling straight through the intersection rather than turning (e.g., diamond interchanges).

Where dilemma zone detection is not provided, provide a single queue loop in each through lane. Place this loop at a distance equal to the 85th percentile speed (fps) x 2 seconds from the stop bar. Provide a single queue loop in each turn lane. Place the loop at the full width point of the pocket or at the same distance calculated for adjacent through lanes if this distance falls closer to the stop bar.

Induction Loops

Induction loops shall be type 3A Stop Line or type 3 Advance loops per WSDOT Standard Plans.

When induction loops are installed in conjunction with new pavement, install the loops before the final lift of pavement has been installed.

The maximum distance from an induction loop installation and its associated junction box is 50 feet.

Dilemma Zone Detection Loop Placement

A speed study is required to determine the typical speeds approaching the intersection. Vehicle speed data should be collected during off peak hours and should only include free flowing vehicles, unimpeded by other vehicles.

Use the following table to calculate the placement of dilemma zone detection loops. Calculate each step in sequential order. Convert 90th percentile and 10th percentile speeds to feet per second in order to use the following formulas:
\[ V_{90} = 90\text{th percentile speeds} \quad V_{10} = 10\text{th percentile speeds} \]

<table>
<thead>
<tr>
<th>STEP</th>
<th>VARIABLE</th>
<th>EQUATION</th>
<th>VALUE</th>
<th>COMMENT(S)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>UDZ(_{90}) (feet)</td>
<td>(\frac{V_{90}^2 + V_{90}}{16})</td>
<td></td>
<td>loop #1 LOCATION. Upstream end of Dilemma Zone (UDZ) For 90th percentile speed (V(_{90}))</td>
</tr>
<tr>
<td>2</td>
<td>DDZ(_{10}) (feet)</td>
<td>(\frac{V_{10}^2 + V_{10}}{40})</td>
<td></td>
<td>Downstream end of Dilemma (DDZ) Zone for 10th percentile speed (V(_{10}))</td>
</tr>
<tr>
<td>3</td>
<td>LC1 (sec)</td>
<td>(\frac{UDZ_{90} - DDZ_{10}}{V_{10}})</td>
<td></td>
<td>V(<em>{10}) travel time from loop #1 to downstream DZ(</em>{10})</td>
</tr>
<tr>
<td>4</td>
<td>Loop Criteria #1</td>
<td>LC1 (\leq) 3.0 sec?</td>
<td></td>
<td>Does V(_{10}) clear in 3.0 sec.? If YES, use Loop #1 only. Stop here. If NO, need 2nd loop. Proceed</td>
</tr>
<tr>
<td>5</td>
<td>PMID (feet)</td>
<td>(\frac{UDZ_{90} + DDZ_{10}}{2})</td>
<td></td>
<td>Potential location for Loop #2</td>
</tr>
<tr>
<td>6</td>
<td>LC2 (sec)</td>
<td>(\frac{UDZ_{90} - PMID}{V_{10}})</td>
<td></td>
<td>V(_{10}) travel time from Loop #1 to Loop #2.</td>
</tr>
<tr>
<td>7</td>
<td>Loop Criteria #2</td>
<td>LC2 (\leq) 3.0 sec.?</td>
<td></td>
<td>Does V(_{10}) clear in 3.0 sec.? If YES, set Loop #2 at PMID If NO, discuss with Wsdot Signals Ops.</td>
</tr>
</tbody>
</table>

**Video Camera Detection**

Permanent Video Camera detection may be considered for specific locations that are not conducive to induction loop installation such as existing bridge decks or severely degraded or rutted pavement.
Permanent Video camera detection may also be considered if the existing pavement is scheduled to be repaired or replaced within a 6 months period. When Video camera detection is installed under this premise, install the required conduit and junction box system to each future induction loop location.

Video camera detection considered for a permanent installation requires the approval of the Regional Traffic Design Engineer.

Install video camera detection systems for temporary vehicle detection within the construction period of a project. In this situation, the temporary video detection system is required to be installed and made operational prior to the existing detection system being disabled and then removed after the permanent detection system is installed and made operational.

When determining the design location of Video detection cameras installed for either permanent or temporary video detection, verify the suitability of the location with the WSDOT Signal Operations Engineer prior to finalizing the design.

**Bicycle Detection System**

When a dedicated bike lane is installed through a signalized intersection, install a bike detection system at the stop line for each bike lane approach. As a default, the detection system should consist of a single induction loop assigned to the same signal phase as the corresponding vehicle through lanes. Current technologies may provide a more efficient and reliable detection system and should be evaluated and considered as an alternative to the induction loops. Alternate detection systems require the approval of the WSDOT Regional Traffic Engineer.

**Emergency Vehicle Pre-Emption**

Emergency Vehicle Pre-emption detector coverage should begin far enough in advance of the intersection to allow termination of the existing signal phase, including the completion of the pedestrian walk interval, and to allow time for all of the stopped vehicles to begin moving. Supplemental detectors may be required to provide the required detection zone. Detector coverage on the approach must be continuous.

Coordinate with the local Fire District to determine if there is a need for additional pre-emption detection coverage for nearby Fire Stations. If the Fire Station is located close to the intersection, it may be necessary to install a Pre-empt detector in the Fire Station to allow immediate activation.
Railroad Pre-Emtion

Provide railroad preemption when there is a signalized railroad crossing within 150 feet of a signalized intersection. Coordinate with the railroad agency, through the WSDOT railroad liaison engineer, to determine the type and function of the interconnect system between the railroad signal bungalow and the traffic signal controller cabinet.

At a minimum the railroad preemption shall utilize the 4-wire Double-Break interconnect system. Replace 2-wire interconnect systems with the 4-wire Double-Break interconnect system when an existing traffic signal system is modified or rebuilt.

Blank Out Signs

In conjunction with a railroad pre-emption system, utilize blank out signs that will prohibit left turn and right turn vehicle from entering the approach with the railroad crossing while the pre-emption is activated.

Traffic Signal Interconnect

Traffic signal interconnect shall be installed with new signal installations per the requirements of the most current version of the WSDOT Design Manual. Traffic signal interconnect should be considered for existing signal rebuild per the most current version of the WSDOT Design Manual.

Traffic signal interconnect between traffic signals shall be fiber optic cable installed in a buried conduit and pull box system.

Junction Box / Pull Box

A junction box shall be provided for each signal pole. Install junction boxes a maximum of 5 feet from each signal pole. Route signal, communications and illumination power, to the signal poles, through separate conduit and junction box systems. It is allowable to combine signal, communications and illumination conductors inside the signal pole as long as all the conductors have an insulation rating of at least 600 volts.

When the signal standard is installed on a slope greater than 3:1, junction boxes associated with the signal standard installation shall be installed in a concrete pad attached to and level with the top of the signal standard foundation. The concrete
pad shall provide a minimum of 12 inches between the junction box and the edge of the pad.

The Type 332D double wide controller cabinet shall be installed with one pull box and one Type 25-TA small cable vault installed adjacent to and within 5 feet of the controller cabinet. The pull box shall route conduit and signal conductors to the traffic signal side of the controller cabinet. The Type 25-TA small cable vault shall route communication cable and conduit to the communication side of the controller cabinet. The pull box and cable vault should be labeled accordingly and there should be no conduit connection between the pull box and cable vault.

The Type 332 controller cabinet shall be installed with one pull box installed adjacent to and within 5 feet of the controller cabinet.

Add instructions to coil all excess conductors and cables in their respective pull box or cable vault.

Junction boxes installed with stop line induction loop splices shall be Type 2 junction boxes or larger.

Traffic signal interconnect systems with fiber optic cable shall utilize pull boxes.

See the GENERAL ELECTRICAL DESIGN section for other requirements.

Signal Cables and Conductors

Two-conductor through 10 conductor unshielded signal control cable shall be 16 AWG size conductors when the associated signal controller and cabinet meet the most current Wsdot Standard Specification requirements. When the signal controller and cabinet do not meet the most current Wsdot Standard Specifications the signal control cable shall be 14 AWG size.

When two sets of dilemma zone loops are installed (multiple through lanes on any approach), the first set of loops farthest from the intersection shall be routed back to the signal controller cabinet on separate 2C(sh) cables. The set of loops closest to the intersection shall be spliced together in the junction box and routed back to the signal controller cabinet with one 2C(sh) cable.

One 4-conductor cable shall be routed between each APS pushbutton assembly and the associated pedestrian signal display housing. The 4-conductor cable shall meet
WSDOT standard specifications or the recommendations of the APS pushbutton manufacturer.

When two pedestrian signal heads are installed on a Type II or Type III signal pole route one 7-conductor cable to the terminal cabinet on the signal pole. Route individual 5-conductor cables to each pedestrian signal display from the terminal cabinet. In all other situations, route a 5-conductor cable from the controller cabinet to each pedestrian signal display.

Use 5C cables between the controller cabinet and signal poles for each signal phase.

Use 2C(sh) cables to route traffic and pedestrian detection back to the controller cabinet. Use 3C(sh) cables to route emergency vehicle preemption detection back to the controller cabinet. 2C(sh) and 3C(sh) cables cannot be spliced (with the exception of the splice that connects induction loops to the 2C(sh) cable) and must run continuously back to the controller cabinet.

The power conductors installed between a service cabinet and a Type 332D double wide controller cabinet shall be sized to accommodate all signal and communication equipment installed in the cabinet and all potential future communication equipment. The minimum size conductor installed between a service cabinet and traffic signal cabinet or UPS cabinet is a #8 AWG conductor.

Route signal control cables and electrical power through separate conduit/junction box systems.

Traffic Signal Power Supply

For double wide Type 332D controller cabinets, the calculated power demand for the cabinet shall include an estimated 3 Kva for future communications equipment requirements. If communications equipment is installed in the cabinet, then the actual calculated load from the communications equipment shall be used for load calculations.

See the GENERAL ELECTRICAL DESIGN section for other requirements.

Uninterrupted Power Supply (UPS)

An uninterrupted power supply (UPS) system shall be installed with each new Traffic Signal controller cabinet installation. The UPS system, including batteries, shall be installed in a separate Type 332 cabinet.
When a UPS is installed with a traffic signal and there is a signalized railroad crossing within 150 feet of the signalized intersection, the UPS running capacity shall equal or exceed that of the signalized railroad crossing UPS system.

The UPS cabinet should be installed close to the controller cabinet, typically on the same foundation pad.

When a communication cable is required between the UPS cabinet and the controller cabinet, the cable shall be installed in a separate 2” communication conduit. When a communication cable is not required, a spare 2” conduit shall be installed between the UPS cabinet and the controller cabinet for future use.

ILLUMINATION SYSTEM DESIGN

Illumination Area Jurisdiction

When designing a new illumination system or evaluating an existing illumination for rebuild, it is important to first determine which agency (wsdot, city or county) will be responsible to own, operate and maintain the illumination system as define in RCW 47.24.020 and WAC 468-18-040, 050. Design standard criteria and direction will be heavily influenced by this determination.

Take into account Maintenance and Operation (M&O) agreements or Memos of Understanding (MUO) between WSDOT and local agencies when determining which design requirements to apply.

If an existing illumination system scheduled to be modified or rebuilt is not being operated or maintained by the appropriate agency, steps should be taken to reassign the illumination system to the appropriate agency. This includes communicating with the local agency involved to determine a course of action. Among other aspects, this may involve a transfer of power supply bill paying responsibilities to the appropriate agency and the reassignment of maintenance and operation responsibilities.
Street Lighting Design Criteria

The current design standard for new and modified existing street illumination systems is to install Type 1 steel light standards with a 50 foot H1 height with the H1 height measured vertically from the luminaire fixture to the light standard base.

When the required mounting height (measured from the luminaire fixture to the roadway surface) requires a shorter light standard, alternate mounting heights, between 20 and 50 feet in 5 foot increments may be used if field conditions preclude the use of the standard design criteria or to match an existing illumination system. Mounting heights over 50 feet are not allowed for light standards without a luminaire fixture lowering device.

The maximum length for Type 1 light standard mast arms is 16 feet. Mast arms shall a minimum of 6 feet in length, designed in whole number increments (i.e. 6, 7, 8 etc.).

Decorative light standards and fixtures may be considered for specific State Route corridors to coordinate with an established regional policy or to match an existing lighting system with decorative light standards and fixtures. Also, decorative fixtures may be considered for local agency lighting systems.

The standard luminaire fixture for 50 foot (or shorter) mounting height light standard is a Type III, medium distribution fixture with cutoff optics. The current standard light source is an LED (light emitting diode) type fixture. Contact the regional Traffic Engineer for the most current acceptable make, model and manufacturer’s for LED light fixtures.

High Pressure Sodium (HPS) lamps shall be used for light standards over a 50 foot mounting height. 400 watt lamps are acceptable. 310 watt lamps shall not be used. 1000 watt lamps are often considered for High Mast installations.

A complete lighting system shall utilize a minimum of two electrical branch circuits serving the luminaires. This ensures that a single failure does not disable the entire system. As an example, if two lights are installed to provide a lighting system at an intersection, then each light shall be powered from a separate circuit from a single electrical service cabinet.

Light Standard Slip Bases

Slip bases are installed as a safety requirement with new or relocated light standards when the light standard foundations are installed in grade, under the following conditions:
Slip bases are installed:

- When light standards are installed on a high speed highway facility, including the full length of on and off ramps, and the light standards are not protected by permanent wall, barrier or guardrail. A highway facility is considered high speed when the posted speed is 50 mph or greater.
- When the light standard is located within the Design Clear Zone as defined in Chapter 1600 of the Design Manual and the light standard is not protected by permanent wall, barrier or guardrail.

The exception to the previous conditions may be when a light standard is installed behind sidewalk without barrier protection and is determined to be within the Design Clear Zone. In this case, consider the pedestrian volumes along the sidewalk as a mitigating factor in installing a slip base. In locations with high pedestrian volumes, perform an engineering analysis to determine if the risk of injury to pedestrians from a dislodged light standard may be of greater concern than the potential hazard to the vehicle occupants. In these situations it may be advisable to install a fixed base light standard in order to minimize the hazard to pedestrians.

**Light Standard Foundations**

Illumination Plans with pole locations and corresponding cross sections, shall be submitted to the Regional Material Engineer for soils analysis and foundation design recommendations. The Materials Engineer will either approve the use of the standard plan foundation design or submit an alternate foundation design recommendation for each location.

High mast Luminaires (H1 over 50 feet) will require a soils analysis from the Regional Materials Engineer and a special foundation design from the State Structural Engineer. Special Design foundations designed by consultant or other agency shall be submitted to the State Structural Engineer for approval.

As an alternative, the soils analysis may be provided by an independent, professionally licensed, Geotech Engineer.

All existing luminaire foundations scheduled for removal shall be removed completely. Remove all wiring from abandoned conduit and backfill the void.
Light Standard Locations

During field investigation for light standard placement, a field survey is required to locate all underground and overhead utilities. Any underground utility found to be within 5 feet of the proposed light standard foundation requires pot holing to accurately determine the exact location and depth of the utility.

A minimum of ten feet of clearance shall be maintained between any Wsdot light standard or structure and overhead utility power lines, including the neutral line. Larger clearance is required for power lines exceeding 50 Kva.

Luminaire poles should be located as far from the travelled way as practical. Poles located within the clear zone of the travelled way will require a slip base installation unless approved protection, such as guardrail, wall or traffic barrier, is provided.

Do not install light standards in environmental impact areas such as wetlands and buffer areas.

Avoid placing luminaires in the bottom of ditch sections or other depressions where water accumulation is likely.

Light standards with slip bases, installed adjacent to the travelled way, will almost always require some level of slope embankment treatment to level out the slope around the light standard location. Provide slope embankment treatment in accordance with the Standard Plans.

Combine light standards with traffic signal standards whenever practical to reduce intersection clutter.

Light standards, including the junction box and conduit system, shall be located inside of Wsdot right-of-way.

Conductor, Conduit and Junction Box System

A junction box shall be provided for each light standard.

When signal or communication equipment is installed on light standards, route the associated cables to the light standard through separate conduit and junction box systems. It is allowable to combine signal, communications and illumination conductors inside the light standard as long as all the cables have an insulation rating of at least 600 volts.
When the light standard is installed on a slope 3:1 or steeper, junction boxes associated with the signal standard installation shall be installed in a concrete pad attached to and level with the top of the light standard foundation. The concrete pad shall provide a minimum of 12 inches between the junction box and the edge of the pad.

Conduit entering a light standard shall be 1” conduit.

The minimum size conductor for lighting systems (except for the pole and bracket cable in the light standards) is #8 AWG.

See the GENERAL ELECTRICAL DESIGN section for other requirements.

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**GENERAL ELECTRICAL DESIGN**

**Electrical Service and Power Supply**

As a design standard, install a Type E, single phase, 480 volt electrical service, as detailed in the WSDOT Standard Plans, for roadway lighting systems and ITS equipment power located on full access control, high speed corridors. A roadway is considered high speed when the posted speed is 50 MPH or higher. Freeway ramp terminals would be considered part of the high speed corridor and will require a Type E service for traffic signals, illumination or ITS equipment.

For arterial streets and other urban locations, install a Type D, single phase, 240/120 volt electrical service, as detailed in the WSDOT Standard Plans for illumination, traffic signal and ITS equipment.

Strut mounted Type B modified single phase, 240/120 volt electrical services may be considered for remote areas, where site restrictions prevent the installation of a pad mounted Type D service. Type B pole mounted services should only be use for temporary installations.

Type C electrical services are not allowed. When existing Type C services are encountered within the project limits, they should be replaced with a new service meeting current requirements.
Electrical service installations shall include all branch breakers and contactors shown in the WSDOT Standard Plan details. Branch breakers not utilized when installed shall be labeled as spares.

Illumination branch breakers and all spare branch breakers shall be rated at 30 amps.

New electrical service installations shall be evaluated to determine the potential ARC flash hazard. Affix a warning tag inside each electrical service indicating the potential ARC flash hazard.

Electrical service installations may require a primary side disconnect switch. Coordinate with the serving Utility Company to determine the requirements for a primary side disconnect switch.

Transformers

Transformers, installed to support traffic signal, illumination or ITS equipment, shall be installed in stand-alone pad mounted cabinets, sized in accordance with the WSDOT Standard Specification manual.

At a minimum, transformers shall be sized to provide a capacity of 150% of the design load on the secondary side of the transformer.

Transformer sizing should be standardized at 5, 7 ½, 10, 15 and 25 Kva. The minimum size transformer shall be 5 Kva.

Each transformer cabinet shall include, at a minimum, one spare 30 amp breaker on the secondary side of the transformer.

Junction Boxes, Pull Boxes and Cable Vaults

Junction boxes or pull boxes shall not be installed in the traveled way or paved shoulder. If this is unavoidable due to right of way or civil design constraints, then junction boxes or pull boxes installed in the traveled way or paved shoulder shall be Heavy Duty type boxes.

Existing junction boxes or pull boxes installed in the traveled way or paved shoulder shall be relocated out of the traveled way. If this is unavoidable due to right of way
or civil design constraints, then junction boxes or pull boxes installed in the traveled way or paved shoulder shall be replaced with Heavy Duty type boxes.

When the conduit runs between junction boxes includes noticeable bends due to horizontal or vertical curves or other terrain features that add additional bends to the conduit run, junction box spacing should be limited to no more than 180 feet.

When the conduit run between junction boxes is relatively straight with very few or no perceptible bends, junction box spacing can extend to a maximum of 300 feet.

Junction boxes and pull boxes shall not be installed in a sidewalk or paved walk/bike path. If this is unavoidable due to right of way or civil design constraints, then junction boxes or pull boxes shall have slip resistant lids and frames. Existing junction boxes and pull boxes installed in sidewalk or paved walk/bike paths shall be replaced with boxes having slip resistant lids and frames or relocated out of the walk/bike areas.

Cable vaults shall not be installed in the traveled way, paved shoulder, sidewalk or paved walk/bike path.

At a minimum, each electrical service cabinet and transformer cabinet installation shall have one Type 2 junction box connected to the cabinet with two 2” conduits.

Existing junction boxes, pull boxes and cable vaults, including the lids, shall be evaluated to determine the condition of the bonding and grounding systems. Those found to be deficient shall be modified to meet the most current requirements for bonding and grounding.

Conduit

In addition to the conduit required to carry conductors or cables to a cabinet, install a spare 2” conduit between each junction box or pull box and any cabinet. Install a spare 3” conduit with each roadway crossing associated with a Traffic Signal system.

Install a spare 2” conduit with all other roadway crossings.

Install a spare 2” conduit between a UPS cabinet and the associated controller cabinet when no communication cable is required at the time of installation.

Install conduit under pavement on State Route highways using the directional boring method. Trenching existing or new pavement on State Routes is not allowed.
Where practical, multiple conduits crossing a highway in the same vicinity, may utilize the same directional boring tunnel. It is acceptable to combine conduits from ITS, Illumination, Signal or power supply systems in the same directional boring tunnel.