NORTHWEST REGION: CURRENT PRACTICES IN ELECTRICAL DESIGN

DESIGN ELEMENTS

SIGNAL PERMIT

No design work shall proceed without an approved traffic signal permit.

GEOMETRY

Locate opposing left-turn lanes in line with each other. Such design not only allows for “Quad” signal operation but also enhances safety. When a left turn lane is located opposite an approaching through lane, the left turning driver may fail to yield to the approaching vehicle having assumed that the approaching vehicle would also turn left.

Consider designing a "through T" at a "T" intersection. This design would allow one direction to flow without having to stop. Normally this results in a more efficient operation.

Avoid construction of skewed intersections. This type of geometry is difficult to signalize and stripe, and causes operational problems. Large curb return radii further complicate matters at such locations.

Proper location of new roadway approaches is critical. Improper location can cause safety, design, operational, public relations and legal problems.

If new roadway approaches are constructed too close to driveways, access from the driveway may have to be restricted to Right In/Right Out, or signalized access may have to be provided for the driveway. Other possible ramifications include having to limit the length of the left turn pocket to provide full access to and from the driveway.

New roadway approaches should either be located directly opposite or as far as possible from any opposing approach. New roadway approaches should also be located as far as possible from adjacent approaches.

Where bus pull-outs are to be installed at an intersection, they should be located at the far side of the intersection for the following benefits:

- Minimizes overall intersection conflict, particularly the right-turn conflict.
- Minimizes impact to the signal operation when buses need preemption to pull out.
- Provides the extra pavement in case U-turn maneuvers are allowed.
- Does not obstruct vision of drivers attempting to turn right on red.
- Does not conflict with right turn pockets.

Curb return radii should be as tight as possible. Use the Design Vehicle turning template and the actual wheel tracking to design the radius. Radii should typically be no more than 35 feet in urban areas. Tight curb radii reduce pedestrian crossing time, reduce signal mast arm length, and discourage high-speed turns. This contributes to a safer, more pedestrian-friendly intersection.

Unless absolutely needed, raised traffic islands should not be used. Conflicting movements are then controlled by the signal and confined to the intersection. This results in increased vehicular and pedestrian safety. A raised traffic island may be used if the right-turn lane becomes an added lane rather than merging into an existing lane on the exit leg of the intersection. When an island must be constructed without the right-turn lane, consider signing for added safety.

Raised traffic islands must meet current ADA requirements. Provide curb cuts for wheelchair ramps at sidewalks and islands per current ADA requirements.

CROSSWALKS AND PEDS

Marked crosswalks serve to guide pedestrians in the proper path. Marked crosswalks should not be considered as safety devices. At locations where traffic is not controlled by a signal or stop signs, marked crosswalks give pedestrians a false sense of security and should be avoided.

The standard number of crosswalks for a “T” intersection is 3. The standard number of crosswalks for a “Four Legged” intersection is 4. Joint approval from the Traffic Analysis Group and the NW Region Electrical Design Section is required to use less than the standard number of crosswalks. The minimum number of pedestrian crossings (striping, displays, detection) is 2 for "T" intersection and 3 for a "Four Legged" intersection.

If a crosswalk is installed across the leg where the left-turning traffic enters, then the vehicle displays shall not contain a left green arrow. If this does not work operationally, a separate pedestrian phase might be warranted.

Locate crosswalks closer to the right-turning traffic. This improves pedestrian visibility.

Install crossing prohibition signs where pedestrian crossing is not allowed.

As a general rule pedestrian push buttons should be located such that the pedestrian would not have to deviate more than 5 feet from the normal path of travel in order to actuate the detector, and in no case shall the pedestrian detector be placed more than 15 feet from the center point at the end of the associated cross walk. Pedestrian push buttons shall be accessible to pedestrians and wheelchair users. When a signal pole must be placed in a location, which would not be accessible to wheelchairs, it may be possible to pave the area leading to the signal pole to provide access. Depending on the location and accessibility of the signal pole, it may be necessary to install separate pedestrian push buttons on type PPB pushbutton posts or on type PS pedestrian head display posts to satisfy the aforementioned requirements.

Audible pedestrian indicators should only be considered when there is a request from a Local Agency or a request from a person using the crossing who is sight impaired or has other challenges for which, the device is needed. Installation requires approval from the NWR Traffic Design Engineer. Note that audible pedestrian indicators are loud and may be a serious nuisance to nearby residents or businesses.

See the attached NW Region Traffic Operations Crosswalks: Policy and Practice .

CONTROL SYSTEM

When a local agency has the only operating coordination system in a corridor, and the WSDOT and Local Agency are in agreement regarding the operation of the system, use controller equipment, which is compatible with the local jurisdictions. Use Type 170 controller equipment if we have a coordination system or if there is no existing coordination system in the corridor.

When used, NEMA controllers should be installed in type 170/332 cabinets using a C1 plug to a NEMA A,B,C,D adapter. The type 170/332 cabinet comes with a model 210 conflict monitor, which can be used with a NEMA controller by flipping a switch. Do not specify a type 12 NEMA conflict monitor when using a type 170/332 cabinet. The type 12 NEMA conflict monitor does not fit in the type 170/332 cabinet and its operation is not compatible with the type 170/332 cabinet. If a NEMA cabinet is used, specify rack-mountings for the loop detector amplifiers and preemption detector amplifiers.

All controller cabinets shall be fully wired for eight vehicular phases, four overlaps and four pedestrian phases. A full compliment of auxiliary equipment shall be installed in the input file.

Coordinate with the electronics technician for direction regarding the door orientation and location where the cabinet is to be installed. The controller shall be located such that a technician or operations engineer will have a clear view of the intersection from its front door. Avoid placing the controller at locations where it might block the view of the right-turn on red vehicles. Also, 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.

Interconnect with other WSDOT signals within a half-mile of the subject intersection.

A spare (empty) 2-inch conduit shall be installed between the controller cabinet and the closest type 2 or type 3 junction box.

If a phone drop is desired by Signal Operations, install a separate junction box and conduit from the controller along with a modem. If a future phone drop is desired, install a separate junction box and conduit from controller.

Terminate all spare wires inside the controller cabinet at a terminal block.

DISPLAY SYSTEM

Signal installations, which will be in place for five years or longer are considered permanent signals. Type II or III steel signal standards shall be used for all permanent signal installations. Type IV or V signal strain pole standards may be used for signal installations, which will be in place less than five years. If a temporary signal system will be in place less than two years timber strain poles may be used.

Use (1) seven-conductor cable for a dual pedestrian display. Use (1) five-conductor cable for a single pedestrian display. Use two-conductor (shielded) cable for each pedestrian detector.

When future vehicle signal display installation is planned on a mast arm, wiring for these displays shall be terminated (with the slack length coiled) in the mast arm and tennons shall be installed for future use.

Maintain 8 feet between all signal displays for a given approach.

Use 12 inch signal lenses. All signal displays shall have backplates.

Install a junction box near each signal pole and route wiring to the pole through the junction box.
In most cases Type M mounting should be used for signal displays. WSDOT requires a minimum 16.5 foot signal head clearance. Signal head clearance shall be limited to provide a vertical viewing angle to the top of the required signal head mounted over the roadway, which is no greater than 20 degrees. The vertical viewing angle shall be measured from a point corresponding to the driver's eye located 8 feet behind the stopbar and 3.5 feet above the roadway. Using this approach, maximum clearances for various situations have been calculated. See detail 2.01E on the Signals, Illumination & ITS Detail Library of the WSDOT Traffic Design homepage at http://www.wsdot.wa.gov/Design/Traffic/Electrical/design_details.htm

Locate signal poles behind sidewalks and junction boxes off of the traveled section of the roadway. Install junction boxes flush with the sidewalk if they cannot be placed behind the sidewalk. Junction boxes shall not be placed in wheelchair ramps.

At every signal pole, provide a terminal cabinet with one spare 12 position terminal block for future use. Terminate all spare wires. Locate the terminal cabinet immediately below the ped display assembly or a minimum of six feet above the pole base if no ped display is provided.

Programmable 3M vehicle signal displays shall not be used unless approved by the Region Traffic Engineer.

Use all arrow displays for left-turn signals if using protected only operation. Use a five section "dog-house" display if using protected-permitted operation.

Use directional, extended visors for appropriate signal displays at a skewed intersection. The intent is to shield visibility of signal displays, which could be seen by 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.

DETECTION SYSTEM

Dilemma zone detection shall be provided in through lanes, where the 85^{th} 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 ramps with little or no traffic traveling straight from the ramp rather than turning (e.g., diamond interchanges).

Where dilemma zone detection is provided, use the attached loop placement worksheet to determine locations for installation of advance loops.

Where dilemma zone detection is not provided, provide a single queue loop. In through lanes, place this loop at a distance equal to the 85th percentile speed (fps) X 2 (s) from the stop bar. In turn pockets 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.

Speed data for placement of traffic loops is obtained for each approach with spot a speed study. Only the lead vehicle in each platoon is considered. Speed study data is gathered during off peak hours in free flow conditions under favorable weather conditions (such that traffic is not influenced by the weather). The person performing the speed study should be as inconspicuous as possible to avoid influencing vehicle speeds. Prior speed study information obtained using this approach which is less than one and a half years old may be used provided conditions which may influence vehicle speeds have not changed in the area. Examples of such conditions include the alignment, channelization and signing.

Loops shall be type R1, R2, or R3 per NW Region Master details. In most cases type R3 loops are used for stop bar detection and type R1 loops are used for advance detection.

When using a Type 170/332 cabinet, assign stop bar loops in an approach to advance detection input (extension) channels if no advance loop is provided in the same approach. This will allow use of the extension feature, which is normally accomplished using advance loops. The extension function helps move the traffic queue through the intersection.

On a multi-lane approach (not counting any separate left-turn lane), the right-hand lane stop bar loop shall have an amplifier whose signal input to the controller can be delayed.

When using more than one set of advance loops on a multi-lane approach, the set of loops furthest upstream shall be brought in on separate lead-ins. The set of loops closest to the intersection shall be wired in series and brought in on the same lead-in.

The distance from a vehicle loop installation and its nearest associated junction box shall be 50 feet or less.

Make sure junction boxes are large enough to accommodate loop splices.

PREEMPTION The responsible Fire District for the area the signal is located in shall be asked:

1. If they want Emergency Vehicle Preemption installed.
1. Which directions they want Emergency Vehicle Preemption installed.

Preempt detector coverage should begin far enough in advance of the intersection to allow termination of the existing signal phase, including the completion of the ped walk interval, and to allow time for all of the stopped vehicles to begin moving. Detector coverage on the approach must be continuous.

Advance fire preemption installation using state funds may be located as far upstream as the limits of the signal system (i.e., advance loop, or advance display) or the companion illumination system.

We normally allow either Opticom or Tomar preemption equipment, provided that the Tomar equipment is able to receive and respond to Opticom emitter signals. If the responsible Fire District prefers Opticom equipment and agrees to pay the difference in cost, Opticom equipment can be required in the contract.

WIRING Communication cable shall not be combined with illumination power circuits of any voltage under <u>any</u> circumstances.

When communication cable is installed as part of a new system, the communication cable shall be kept separate from all other wiring.

When communication cable is installed within the limits of an existing signal system, the communication cable shall be kept separate from all other wiring, with the exception that it may be combined with signal power circuits which are 120 volts or less, such as a five conductor for signal heads. If possible, however the communication cable should be kept separate.

Signal power and traffic loop wiring may be combined with illumination power, provided that all conductors in the raceway have an insulation rating equal to at least the maximum circuit voltage applied to any conductor within the raceway.

SOILS All signal pole foundation design work requires a soil investigation. Existing bore information may be available from District Materials.

POWER

CLEARANCE A minimum of ten feet distance (circumferential) shall exist between power lines including neutral wires and any signal or illumination structure.

SERVICE Service cabinets shall meet EUSERC standards. The current Standard Plans have been revised to meet these requirements. Type A or C service cabinets are no longer allowed.

UPS SYSTEMS It is not Northwest Region current practice to install uninterruptible power supply systems (UPS) for traffic signal systems. However, the Northwest Region has installed and may install UPS for signals as part of ongoing research.

The purpose of this research is to determine benefits verses the cost of installing UPS's for NWR signal systems. In addition, to determine under what conditions or circumstances warrant the installations of UPS systems in our Region.

Installation of UPS systems requires the approval of the NWR Traffic Engineer.

SIGNAL OPERATIONS

LANE UTILIZATION When analyzing multiple lane traffic movements at an intersection, make sure that lane utilization assumptions are realistic under local conditions. Assuming an even split of the traffic volumes over multiple lanes can result in an incorrect estimation of traffic flow efficiency under signalized conditions.

SIGNAL PHASING Minimize the number of signal phases used by providing separate left-turn phases only when the need is established per the Region's Warrants for Left-Turn Phasing.

See the attached protected-permissive left turn operation criteria if this type of operation is being considered. Consult the signal operations Engineer responsible for the area for additional input and recommendations.

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. It is possible to prevent the yellow trap by operating the signal with a recall to the side street, however this is not an efficient manner of operation and should be avoided.

If a left-turn phase is not being used but a detector is installed in the left-turn lane, assign that detector a left-turn detector number and a complementary amplifier in the left-turn phase slot. However, provide a jumper wire between the left-turn output and an extension input channel for the adjacent through movement.

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 either the northbound or the eastbound movement, depending on the mainline orientation.

SIGNALIZED INTERSECTION WARNING ASSEMBLY

Where visibility requirements in Table 4D-1 of the MUTCD cannot be met or where the operating speed is 55 MPH or above and the intersection is more than two miles away from the adjacent signalized intersection, install a signalized intersection warning sign (SIW) assembly to warn unfamiliar motorists of the signal installation on the high speed facility. The SIW assembly consists of a modified 48" x 48" W3-3 sign on a black back plate, two 8-inch yellow signal displays, flasher circuit activated continuously by a separate circuit from the service, and a lighting circuit. Locate the sign per condition "A" of Table 2C-4 of the MUTCD.

INTERSECTION DESIGN AREA

For the purpose of determining lighting requirements at intersections, the intersection design area is defined as the area bounded by the stopping points. Where no marked stop bars are present, this area is bounded by a line perpendicular to the approaching leg, which is ten feet back from the extension of the intersecting street.

NORTHWEST REGION

Traffic PS&E Preparation

CADD BASE PLAN REQUIREMENTS

The base plan needs to contain the following if they apply specifically to this project.

- North Arrow, Township and Range
- Existing and Proposed Alignment
- Existing and Proposed Right of Way, Limited Access and Easements
- Existing and Proposed Channelization
- Existing and Proposed Striping (crosswalks, stop bars)
- Existing and Proposed Utilities (overhead/underground)
- Existing and Proposed Drainage
- Existing Illumination System[1]
- Existing Traffic Signal System[2]
- Existing SC and DI System
- Existing Signing
- CADD File Documentation Sheet

All of the items listed above must be contained in <u>one</u> CADD file.

---

[1] Light standards, conduit runs, junction boxes, electrical service cabinet with service agreement number. Depending on the nature of the work it may be necessary to survey any or all of these items. Signal Maintenance will assist in locating these elements in the field on request. Once surveyed it is imperative that the information is accurately included in the base plan. (South Supervisor – Rich Loucks --206-764-4010) (North Supervisor -- Rick Hardin -- 425-339-1777 [SCAN 261]).

[2] Same as Footnote 1 with the addition of signal poles and signal controller cabinet. Signal poles, controllers, electrical service, junction boxes and all other above ground improvements at traffic signal intersections must be shown accurately, this will require a survey.

<u>Note</u>: Base plans have been prepared incorrectly by using As-Builts as the only source of information on existing features, this approach has cost many preliminary engineering dollars and has also had a negative impact on project scheduling. We assume the data you provide to be correct and verify it only if something appears to be grossly wrong.

<u>Please direct questions to:</u>

Chris Trotter, King County Team Supervisor
Ph. 206-440-4377

Valerie Lee, Snohomish/Baker Team Supervisor
Ph. 206-440-4379

Mosen Janka, ITS Supervisor
Ph. 206-440-4476

Laurinda Anglin, Signing Specialist
Ph. 206-440-4923

NOTE: THE BASE PLAN CADD FILE SHALL BE PER THE PLANS PREPARATION MANUAL.

In order for us to have a complete understanding of the project, we also need copies of the following:

- Approved Channelization Plan
- Traffic Analysis
- Project Summary (Prospectus)
- Project File (Design Report)
- Signal Permit
- Roadway Sections

Engineering back up data to support all illumination design shall be submitted along with the PS&E for each project.

Items 1 through 3 shall be furnished along with the Preliminary Illumination Plan for Approval (approximately 30 percent complete).

1. Design Summary. This summary shall identify and document Roadway Classification, Area Classification, and Design Light Level requirements. The summary shall also identify the deficiencies of the existing system and proposed mitigation, impacts to the existing system due to site preparation or other proposed work and other Projects with concurrent work or future work in area.

2. Warrant Analysis to provide continuous illumination or justification to provide less than basic illumination.

3. Illumination calculations to support luminaire type, distribution, wattage, mounting height, spacing and service voltage to achieve the required design light level. H1 height calculations to achieve proposed mounting heights. Attach cross sections for review.

Items 4 through 10 shall be furnished along with the 70 percent PS&E submittal.

4. Electrical load calculations and line loss calculations to support breaker, wire, and lighting contactor sizing where applicable for each electrical circuit to be included in the contract. Load balancing is required for three phase services.

5. Calculations to support transformer sizing, and transformer over current protection.

6. Conduit fill and junction box capacity calculations.

7. Service load calculations.

8. Utility Agreement and Utility Relocation Requests.

9. Permission from bridge for attachment to structures or installations, which would affect structures.

10. Soils data request and response.

Items 11 through 13 shall be furnished along with the 90 percent PS&E submittal

11. Documentation for design decisions:
    - Use of nonstandard equipment such as decorative poles, fixtures, etc. Attach catalog cuts and data.
    - Deviation from standard practices.
    - Use of salvaged materials.
    - Use of state furnished materials.
    - Other commitments by the State.
12. Approval for use of proprietary items where applicable.

13. Itemized construction cost estimate for each lump sum bid item if WSDOT participates in project funding.

After Final Plan Review comments have been incorporated into the PS&E and the contract plans have been distributed for advertisement, two complete sets of back up data, revised to reflect design changes, shall be submitted.

One set of back up data and copies of the correspondence file will be sent to the Construction PE for use during contract administration. The second set will remain in the Electrical Design office with the design files.

NORTHWEST REGION
TRAFFIC SIGNAL DESIGN
ENGINEERING BACK UP DATA REQUIREMENTS

Engineering back up data to support the traffic signal design shall be submitted along with the PS&E for each project.

Items 1 through 7 shall be furnished along with the Preliminary Signal Plan for Approval (approximately 30 percent complete).

1. Speed study data indicating 90^{th}, 85^{th} and 10^{th} percentile speeds for all approaches.

2. Peak hour turning movement counts (a.m., midday, and p.m.).

3. Loop placement calculations based on the WSDOT Northwest Region Method.

4. Phasing analysis to support protected or protected-permitted left-turn phasing. If protected-permitted left-turn phasing is planned, provide verification that conditions are suitable for this type of operation. (See attached list of factors to be considered in making this determination.)

5. Design Summary. This summary shall identify and document Roadway Classification, Area Classification, and Design Light Level requirements. The summary shall also identify the deficiencies of the existing system and proposed mitigation, impacts to the existing system due to site preparation or other proposed work and other Projects with concurrent or future work in the area.

6. Illumination calculations to support luminaire type, distribution, wattage, mounting height, spacing and service voltage to achieve required design light level. H1 height calculations to maintain mounting heights. Attach cross sections for review.

7. A1 and A2 height calculations for proposed and future phasing to verify minimum/maximum allowed roadway clearances. Attach cross sections for review. In the case of span wire installations, calculations and cross sections are required to verify that roadway clearances will be within the allowable range. See vertical clearance requirements under “Display System”.

Items 8 through 14 shall be furnished along with the 70 % PS&E submittal.

8. Windload calculations for signal mast arms for proposed and future phasing conditions to support foundation sizing. Attach soils analysis for each signal standard to verify foundation design. Attach back up design data for all special designs. In the case of span wire installations, strain pole class and foundation selection calculations are required to support the design.
9. Service load calculations.

10. Utility Agreement and Utility Relocation Requests.

11. Permission from OSC Bridge and Structures for attachment to structures or installations, which would affect structures.

12. Electrical Load calculations and line loss calculations to support breaker, wire and lighting contactor sizing where applicable for each electrical circuit to be included in the contract. Load balancing is required for three phase services.

13. Calculations to support transformer sizing, and transformer over current protection.

14. Conduit fill and junction box capacity calculations.

Items 15 through 17 shall be furnished along with the 90 % PS&E submittal.

15. Documentation for design decisions:

- Display type—mast arm, metal or timber strain pole
- Controller type
- State furnished materials
- Other commitments by the state

16. Approval for use of proprietary items where applicable.

17. Itemized construction cost estimate for each lump sum bid item if WSDOT participates in project funding.

After Final Plan Review comments have been incorporated into the PS&E and the contract plans have been distributed for advertisement, two complete sets of back up data, revised to reflect design changes, shall be submitted.

One set of back up data and copies of the correspondence file will be sent to the Construction PE for use during contract administration. The second set will remain in the Electrical Design Office with the design files.

SR ___ L-_____ PIN _____ Loc. Engr _____

Title _____

Designed By _____ Date _____

Checked By _____ Date _____

_____ Illumination _____Traffic Signal _____ SC&DI

_____ Temporary Illumination _____Temporary Signal _____Temporary SC&DI

Compare Previous Approvals

1. Review Final Project Summary (formally called Project Prospectus).
2. Review Consultant's Scope of Work (if applicable).
3. Review traffic analysis (for geometry and phasing).
4. Review Project File/Design Report (are we in compliance with electrical scope of work?).
5. Design conforms to Approved Channelization Plan.
6. Status of signal permit (permit number and warrant analysis).

Plans - General

1. Township, range, subdivision, north arrow, scale bar each sheet.
2. Project title block blank (intentionally).
3. Sheets identified in lower-left corner.
4. Local Agency and state aide seals and signatures (if applicable).
5. Consultant seals and signatures.
6. Consultant written consent to revise plan.
7. All plan sheets in proper order (signal plan, wiring plan, phasing plan, pole plan, details). Use SHEET REFERENCE number system (E1. . ., TS1. . .,IL1. . ., etc.).

8. No combination of ink and pencil.

9. Plan symbols in accordance with chapter 5 - legend.

10. Minimum lettering height 1/8" (0.125 inch for 24" x 36" sheets).

Summary of Quantities

1. All necessary groups per Chapter 3.

2. Separate groups for agreement work (participating local agencies, etc.).

3. Review for nomenclature, standard item numbers.

Illumination Plans, Schedules and Details

1. Areas, which need lighting illuminated per standards.

2. Temporary illumination needs identified and addressed.

3. System is constructible.

4. Plans are biddable. Plans clearly define what is expected from the contractor.

5. Plans are cost effective.

6. Plans are coordinated with future work in the area.

7. There are no conflicts with existing features. Locations of overhead and underground utilities, drainage, sidewalks, driveways, walls, etc.—Verified in Field (Surveyed). Underground utilities potholed and surveyed at locations of possible conflict.

8. There are no conflicts with proposed features. Electrical system is coordinated with proposed features.

9. Plans coordinated with bridge plans where applicable.

10. Plans provide power for ITS and illumination of signing where applicable.
11. The system can be maintained safely and economically.

12. Existing system deficiencies have been identified and addressed - (Was maintenance contacted for input? Were existing circuits meggered? Is existing wire or conduit aluminum?).

13. Site preparation impacts to existing system identified and addressed where applicable.

14. All work within R/W or construction permit areas.

15. Luminaire schedule matches plan quantities (including type III and V signal poles from traffic signal).

16. Median barrier light standard sections included in lump sum are deducted from the lineal foot barrier quantity. Dimensions of median barrier light standard sections, which will vary are not shown as fixed dimensions.

17. Verify protection for light standards as required in design manual, or use of slip base design.

18. Applicable NEC requirements are satisfied.

19. Conduit is routed across the roadway by the appropriate method (see the attached information on this subject).

20. Where boring or jacking methods are used for conduit crossings, the appropriate depth for the crossing is given to avoid underground utilities. Depth of underground utilities verified (potholed if necessary).

21. Adequate room available for boring/jacking pit and associated receiving pit (minimum size for boring pit is 10 ft. wide by 22 ft. long - in direction of bore, 23 ft is preferred. Is adequate R/W available? Will the pit conflict with utilities or other improvements?).

22. Wire Schedule, including Electrical Service Agreement number:
    - Lists only existing wiring to remain and new wire to be installed
    - Service number and voltage
    - Wire continuity
    - Wire ampacities, ampacity reduction for multiple conductors in raceway
    - Line loss calculations
    - Conduit and junction box sizing

23. Electrical Service
    - Appropriate type is called for - (type A or C services are no longer allowed)

- Reference Standard Plans where applicable
- Provide detail sheet only for modified cabinets
- Breaker/contactor schedule - calculations required
- Transformer - sizing and over current protection calculations required
- Service Agreement number and voltage on plans

24. No j-boxes in unfused power run between power drop and service.

25. All plan symbols appear in Legend and all Legend symbols appear in the plan.

26. Review Construction Notes for clarity and precision.

27. All cross references checked.

28. All "enter data" fields filled (CADD fill-ins).

29. Applicable NW Region Electrical Details have been incorporated.

30. Necessary job specific special details are provided. Details are correct and referenced.

31. Applicable portions of NW Region and general special provisions incorporated.

32. Necessary job specific special provisions included.

33. Design accomplished on the plans and not left to the contractor.

1. Channelization plan is approved and correct channelization is shown on signal plan.

2. Plans are constructible.

3. Plans prepared per Northwest Region Current Practices in Signal Design.

4. Stability of existing signal poles will not be undermined by installation of new signal poles, or can and will be maintained by contractor during excavation and curing of foundation.

5. Changeover impacts should be minimized when practical (is temporary signal needed?).

6. Plans are biddable. Plans clearly define what is expected from the contractor.

7. Plans are cost effective.

8. Plans are coordinated with future work in area.

9. There are no conflicts with existing features. Locations of overhead and underground utilities, drainage, sidewalks, driveways, walls, etc. - verified in field (surveyed). Underground utilities potholed and surveyed at locations of possible conflict.

10. There are no conflicts with proposed features. Electrical system is coordinated with proposed features.

11. Plans are coordinated with bridge plans where applicable.

12. The system can be maintained safely and economically.

13. Existing system deficiencies have been identified and addressed - (Was maintenance contacted for input? Were existing circuits meggered? Is existing wire or conduit aluminum?).

14. Site preparation impacts to existing system identified and addressed where applicable.

15. All work within R/W or construction permit areas.

16. Queue loops installed where applicable - (was Signal Operations contacted for input?).

17. Plans prepared per attached NW Region standard loop numbering sheet.

18. Signal Display Chart matches plan quantities, numbering scheme and phasing.

19. Wire Schedule, including Electrical Service Agreement number and voltage:
    - lists only existing wiring to remain along with new wire to be installed.

- wire continuity
- wire ampacities
- line loss calculations
- conduit & junction box sizing
- loop lead-ins < 1000 ft.
- sawcuts < 50 ft.

20. Electrical service:
    - appropriate type is called for - (type A or C services are no longer allowed)
    - reference Standard Plans where applicable
    - provide detail sheet only for modified cabinets
    - Breaker/Contactor Schedule - calculations required
    - transformer - sizing and over current protection - calculations required
    - Service Agreement - number and voltage on plans

21. All plan symbols appear in the Legend and all Legend symbols appear in the plan.

22. Review Construction Notes for clarity and precision.

23. All cross references checked.

24. All "enter data" fields filled (CADD fill-ins).

25. Corner enlargements for clarity as necessary.

26. Intersection numbering scheme if more than one signal on project.

27. Interconnect cable (communications) if required - local master for coordinated systems?

28. No junction boxes in unfused power run between power drop and service.

29. Telephone communications (if required by signal operations Engineer).

30. Verify preempt detector number against preempt table on phasing sheet.

31. Mast arm standards placed/protected to minimize likelihood of being struck (located outside of clear zone if possible). Minimum shy distance provided per design manual requirements.

32. Verify protection or slip/breakaway base design for non-mast arm signal standards within clear zone.

33. Mast arms, tennons evaluated for maximum ultimate windload and tennons for future signal heads provided.

34. Applicable NW Region Electrical Details are incorporated.

35. Necessary job specific details are provided. Details are correct and referenced.

36. Applicable portions of NW Region and general special provisions are incorporated.

37. Necessary job specific special provisions included.

38. Design accomplished on plans and not left to the contractor.

Wire Termination Plan

1. Use IMSA cable, modify wire termination sheet to reflect IMSA color codes and cable count.
2. Pole numbering matches signal plan.
3. Five conductor coiled in mast arm if left-turn phase not provided.
4. Vehicle and ped display numbering matches signal plan and phasing.
5. Preempt detector and wiring as required.
6. Interconnect wiring (communications) as required.
7. Only field wires to be installed by contractor shown on terminal blocks and output file (170) corresponds with signal plan wiring.

Phasing Plan

1. Phasing coordinated with signal operations and verified against traffic analysis?
2. Signal plan layout matches phasing.
3. Input file labeling corresponds to vehicle/ped detection shown on signal plan.
4. Display panel corresponds to input file.
5. Preempt phasing schedule if preemption provided.

Signal Standard Detail Plan

1. Pole numbering and type correspond to signal plan.
2. Pole A1 lengths verified (back up calculations required).
3. Pole A2 lengths (if required) coordinated with Luminaire Schedule.
4. All pole attachments verified, including future attachments.
5. Permanent signing (if required) coordinated with permanent signing plan and sign spec. sheet.
6. Windloads calculated (signal displays and signs - present/future).
7. Foundation depths determined based on results of soils analysis.
8. Special conditions noted or referenced to special provisions.
9. Foundation orientation angle - P.O.A. (only one per pole).

Electrical Service

1. Use Standard Plans for type D, E, or type B modified Service. Include Breaker Schedule on the signal plan sheet.
2. Include electrical service detail sheet when electrical service is different from Standard Plans.
3. Transformer details.

Traffic Control Plans

1. Review traffic control plans.
2. Temporary traffic signal system required - or phased modification to existing during construction?
3. Temporary illumination system required - or phased modification to existing during construction?
4. Temporary SC&DI system required - or phased modification to existing during construction?

Special Provisions

1. All special provisions entered into computer (MS WORD). Disk to Plan Review.
2. Check Amendments and GSP's against up-to-date index list.
3. Time for completion provision for state furnished electrical equipment (controllers and poles).
4. Use current version of applicable NW Region Electrical Specifications.
5. Verify salvaged materials with Signals Maintenance.
6. Pay Item must match Summary of Quantities.
7. Verify references to Standard Specs and Standard Plans.

Engineer's Estimate

1. Pay Items must match Summary of Quantities.
2. Hard copy of lump sum estimates for submittal (excel template)
3. Furnish quantity take offs for in-house reviewer

Agreement Processing

1. Have necessary Utility Agreements been processed - (Electrical Service Agreement, Telephone Service Agreement, Railroad Agreement, Utility Relocation Request's)?

2. Have necessary participating agreements been processed - (Local Agency, Developer, etc.)?

3. Have necessary Construction Permits been processed?

4. Have necessary Maintenance and Operation Agreements been finalized?

Transmittal Letter - ELEC PS&E TO FO

1. Number of plan sheets being submitted.

2. CADD information - attach completed file documentation sheet.

3. Include or note advance submittal of special provisions.

4. Bid items, including L. S. estimate - attach back up data.

5. Describe status of agreements, permits, and foundation information if pending.

Other Issues to Consider

1. Induction loop sealant compatible with pavement material?

2. Adverse soil conditions? Water table? Foundations for light standards and signal poles adequately sized?

3. Review the latest Northwest Region Current Practices in Signal Design.

4. Adjusting junction boxes to grade? Will adjustment of conduit to maintain 6" to 8" clearance be necessary? Will new wire be required to maintain proper slack?

5. Signal plan in agreement with Channelization/Paving/Striping plans? Verify loop locations.

6. Material specifications in special provisions, not plans.

7. Where foundations will be installed on slopes provide detail to assure foundations will be flush with grade.

Comments

PROTECTED-PERMISSIVE LEFT TURN OPERATION CRITERIA

When evaluating an intersection for protected-permissive left turn operation, field observation and application of sound Engineering judgment are necessary. The following factors shall be considered:

1. If a signal is being installed at a location where the accident warrant is met, and left turn accidents are included in the warranting accidents, protected-permissive phasing shall not be used.

2. If documentation shows that existing protected left turn phasing was installed due to left turn accidents, protected-permissive phasing shall not be used.

3. If sight distance is limited or if there are gaps where approaching vehicles are not visible (say due to a sag curve), protected-permissive phasing shall not be used. Protected-permissive phasing shall not be used unless sight distance for a stopped vehicle turning left against opposing traffic meets the requirements outlined in AASHTO Green Book, Chapter on Sight Distance, Case V.

4. If confusion would result due to the character of the channelization or geometry, protected-permissive phasing shall not be used.

5. If the vehicle making the left turn has to cross three or more opposing through lanes protected-permissive phasing shall not be used.

6. If the 85^{th} percentile speed is above 45 mph, protected-permissive-phasing shall not be used.

7. If converting existing protected left turn phasing to protected-permissive phasing make sure minimum vertical clearance requirements will be maintained.

8. Protected-permissive phasing shall not be used in conjunction with dual left turn lanes.

9. Where left turn movements occur on opposing approaches, protected-permissive phasing shall not be installed for either of the approaches unless both of the opposing approaches will operate with protected-permissive phasing.

10. Consider approach grades when evaluating an intersection for protected-permissive operation. Vehicles making the left turn movement during the permissive period, may stall out or have difficulty clearing the intersection due to the grade, especially when the roadway is wet or covered with ice.

11. If there are numerous access points adjacent to an intersection where cars may enter unexpectedly, the location may not be a good candidate for protected-permissive phasing.

12. If motorists tend to use the opposite shoulder as a driving lane for right turns, the location may not be a good candidate for protected-permissive phasing.

Conduit Crossing Using Jacking, Drilling, and Boring with Casing Methods

Definitions:

"Jacking" is placement of conduit under roadway by threading a pointed tool on the end of the first piece of conduit and then forcing the conduit through the soil by mechanical means -usually hydraulic pressure.

"Drilling" is placement of conduit under the roadway by first drilling a same size hole with an auger, then removing the auger and placing the conduit in the void created by the auger.

"Boring with Casing" is a combination of jacking and drilling with the following modifications. A large diameter steel casing is placed under the roadway into which conduit or conduits will be placed after the boring operation is completed. An auger is located inside the casing and as the auger removes the soil the steel casing is jacked ahead under the roadway.

"Directional Boring" is placement of conduit under the roadway using a surface launched steer-able high-pressure fluid jet drilling tool. Drilling fluid is used to maintain the stability of the tunnel, reduce drag on the conduit and provide backfill between the conduit and tunnel. A guidance system is used to measure the depth, lateral position and roll of the tool head while creating the pilot hole. Once the pilot hole is established, a reamer, a swivel and the conduit are attached to the end of the boring tool and the conduit is then pulled back into the tunnel. Multiple conduits may be pulled back into the pilot hole at the same time.

Current Practice:

When routing conduit across State owned and maintained roadways, conduit shall be installed using the "Directional Boring" method with the following exceptions:

When the work includes a full depth overlay through the area of proposed conduit placement, open trenching may be considered as an option however open cut trenching shall never be used on existing limited access freeways.

Where multiple conduits are routed across the roadway the "Boring with Casing" method may be used in lieu of the "Directional Boring" method. Electrical and SC&DI crossings shall be combined where possible.

When crossing two lanes or less the designer may allow "Jacking" or "Drilling" as an alternate to "Directional Boring" provided soil conditions are suitable. The alternate method would be used at the contractors risk.
Use new construction, bridge structure or bridge rails to cross freeways where cost effective.

SR _____ _____ _____LEG	POSTED SPEED = V90 = V10 =	_____ L- _____ CALC. _____ CHCK. _____

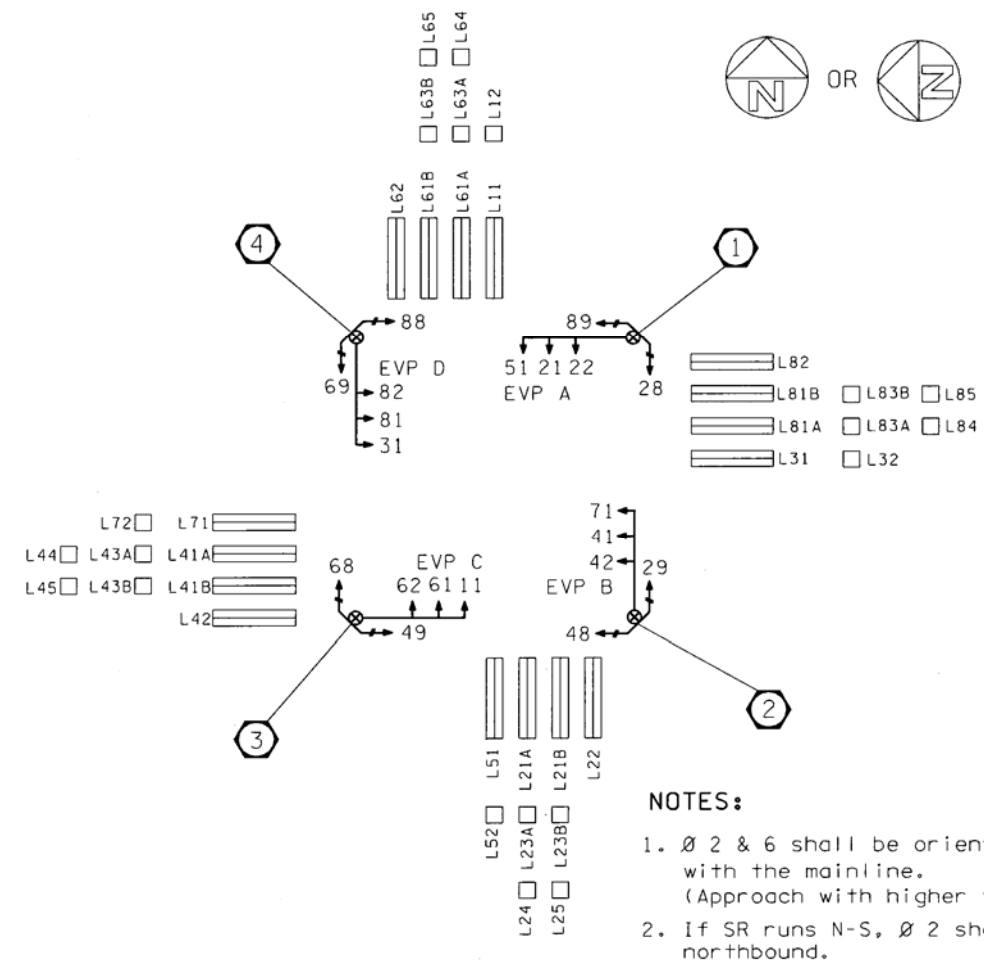
Placement of Advance Loops

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

Important Note:
1. V_{90} , V_{10} Are Measured in (feet/sec) or FPS.

Notes:
1. Original form issued 5/11/83.
2. Revise Step 5. Mathematical operation should be addition (in numerator), not subtraction. (8/3/83)
3. Revise Step 1. Change denominator from 20 FPS^2 to 16 FPS^2. [Deceleration rate is changed from 10 FPS^2 to 8 FPS^2 .] (1/16/83)
4. Revise Steps 4 and 7. Change accepted minimum gap from 2.5 seconds to 3.0 seconds. (3/12/84)
5. V_{90}, V_{10} are results of speed study, not 90 percent and 10 percent of posted speed. (4/18/95)
6. Assumes reaction time of 1 second. (4/18/95)
7. Significant grade will change these calculations. Discuss with signal operations if greater than + or – 4 percent. (4/18/95)
8. Use 1 second reaction time. (6/17/97)

NORTHWEST REGION
STANDARD LOOP NUMBERING



NOTES:

1. Ø 2 & 6 shall be oriented with the mainline. (Approach with higher volume.)
2. If SR runs N-S, Ø 2 shall be northbound.
3. If SR runs E-W, Ø 2 shall be eastbound.
4. Stop bar loops designated LX1A and LX1B shall have separate lead-in cables.
5. Stop bar loops designated LX2 shall be used in exclusive RT lanes.

LEGEND

- LXXX — INDUCTION LOOP
- VEHICLE DISPLAY
- PEDESTRIAN DISPLAY
- POLE NUMBER