Standard E1 Roadside Power Distribution

E1.1 General

This standard describes the design of individual electrical power circuits for illumination, signal, and ITS equipment, powered from WSDOT electrical service cabinets, and the associated features required in the service cabinet to support these circuits. This standard only addresses fixed (or nearly fixed) loads on single phase systems. For variable loads such as motors, or three phase systems, contact the WSDOT Headquarters Traffic Office. This standard also does not address any moveable bridge, marine terminal, vessel, or related electrical systems.

Only one electrical system may be run through any connected conduit, junction box, or piece of equipment, with the sole exception of a separate supply entering an electrical service or transformer cabinet. For WSDOT, each electrical service cabinet and transformer is considered a separate electrical system. For example, wiring from the load side of a transformer cabinet may not use any of the same conduit or junction boxes as wiring from the electrical service cabinet supplying the transformer. Exceptions may be allowed for special equipment requiring multiple input voltages with approval of the Region Signal Maintenance Manager.

E1.2 Standard Load Sizes

Electrical circuits shall be designed using the following standard electrical loads. For equipment other than cabinets, including transformer cabinets, and luminaires (lights), the actual rated load of the equipment shall be used. Due to variations in cabinet equipment and actual loads drawn by different luminaires in the same wattage class, WSDOT has established standard load tables for equipment. These tables are divided into three categories: LED Luminaires, HPS Luminaires, and Cabinets.

Table E1.2-1; WSDOT LED Luminaire Standard Loads

Wattage Class	120V Amps	120V Watts	240V Amps	240V Watts	480V Amps	480V Watts
200	0.93	106	0.46	106	0.23	106
250	1.34	161	0.66	161	0.29	161
310	1.74	207	0.89	207	0.46	207
400	2.23	268	1.12	268	0.56	268
750	4.10	500	2.40	500	1.00	500

Table E1.2-2; WSDOT HPS Luminaire Standard Loads

Wattage Class	120V Amps	120V Watts	240V Amps	240V Watts	480V Amps	480V Watts
100	2.2	130	1.1	130	0.6	135
150	1.7	188	0.9	188	0.5	188
200	2.2	240	1.1	240	0.6	240
250	2.6	300	1.3	300	0.7	300
310	3.4	365	1.7	365	0.8	367
400	4.0	472	2.0	472	1.0	472
750	6.8	840	3.5	840	1.8	840
1000	9.5	1102	4.7	1102	2.4	1102

Table E1.2-3; WSDOT Cabinet Standard Loads

Wattage Class	120V Amps	120V Watts	240V Amps	240V Watts	480V Amps	480V Watts	Standard Transformer Size
1800	15	1800	7.5	1800	3.8	1800	N
2000	16.7	2000	8.4	2000	4.2	2000	N
2500	20.9	2500	10.5	2500	5.3	2500	N
3000	25	3000	12.5	3000	6.3	3000	Y
3500	29.2	3500	14.6	3500	7.3	3500	Y
4000	33.4	4000	16.7	4000	8.4	4000	Y
4500	37.5	4500	18.8	4500	9.4	4500	Y
5000	41.7	5000	20.9	5000	10.5	5000	Y
7500	62.5	7500	31.3	7500	15.7	7500	Y
10000	83.4	10000	41.7	10000	20.9	10000	Y
15000	125	15000	62.5	15000	31.3	15000	Y
25000	208.4	25000	104.2	25000	52.1	25000	Y
37500	312.5	37500	156.3	37500	78.2	37500	Y

Individual luminaires and transformer cabinets shall use the appropriate load data from Tables E1.2-1, E1.2-2, or E1.2-3 as applicable.

E1.2(1) Transformers

The minimum allowable size for standalone transformer cabinets is 3000W. Determine transformer size by calculating the total load connected to the transformer, and then multiply this value by 1.33.

Example:

- 6000W (or 6 kVA) of load is supplied by a transformer
- 6000W x 1.33 = 7980W
- Minimum transformer size is 10000W (or 10 kVA), as 7980W is above 7500W (next lower standard size)

The additional 33% allows for future additional load without the need to replace the transformer. Transformers are available in any of the wattage classes listed in table E1.2-3, from 3000W up. These are standard sizes, so the next higher size than the calculated load must be selected.

E1.2(2) Equipment Cabinets

For traffic signal and ITS cabinets, there is a minimum standard load which must be used for each type of cabinet. These minimum standard loads are listed in Table E1.2-4A and Table E1.2-4B.

Table E1.2-4A; WSDOT Minimum Standard Cabinet Loads for Single-Width (33x) Series Cabinets

Cabinet Includes	Minimum Wattage Class
Ramp Meter (RM)	2500
Traffic Signal (SG)	3000
Variable Message Sign (VM)	3500
Tolling	4500
All Other 33x	2000

Notes for Table E1.2-4A:

1. Traffic Signal Cabinets include NEMA Traffic Signal Cabinets (such as a P44 cabinet).
2. VMS Systems may not be installed in double-width cabinets at this time.

Table E1.2-4B; WSDOT Minimum Standard Cabinet Loads for Double-Width (33xD) Series Cabinets

Cabinet Includes	Minimum Wattage Class
Ramp Meter (RM)	3000
Traffic Signal (SG)	4000
Tolling	4500
All Other 33xD	2500

Note for Table E1.2-4B: Type 342LX cabinets use the same standard load as Type 33xD Traffic Signal Cabinets.

Cabinet loads may be higher depending on the equipment installed. Selected cabinet load ratings must be approved by the Region Signal Maintenance Manager to ensure adequate circuit capacity. All cabinets, with the exception of transformer cabinets and some VMS cabinets, operate on 120V. All other loads shall initially be determined using 240V or lower. Additional criteria in Section E1.3 will determine if a 480V circuit may be used.

E1.3 Wire Size

Wire size for a circuit shall be determined using a combination of ampacity (total amps that can safely be carried) and line loss requirements. These values are determined for each segment in the circuit. Wire sizes may not decrease along a circuit when moving from any end load to the electrical service cabinet.

The length of a circuit segment (L_S) is the horizontal physical length of the conduit between the two opening points plus 10 feet, to account for sweeps and slack. Where wire is routed up a pole (such as to an aerial circuit connection), add the height of the pole to the ground segment length connected to that pole.

At light standards, there is a segment from the junction box to the pole base, and a second segment from the base to the actual luminaire. As with other conduit runs, the circuit segment length of the between the box and the pole is the horizontal physical conduit length plus 10 feet. For the wire in the pole itself, the length of the segment is the height of the pole (H1 height) plus the length of the luminaire arm (example: a 40 ft pole with a 12 ft arm would have a segment length of 52 ft). The segment in the pole is always #10 copper wire (Pole and Bracket Cable).

Ampacity and line loss depend on the type of wire selected. Aluminum wire may only be used under the following circumstances:

1. Aerial triplex wire installation. This is normally only temporary, though some long-term installations do exist.
2. In locations with repetitive wire theft. Requires approval, or prior direction, from the Region Signal Maintenance Manager.

Copper wire must be used for all other cases.

To check ampacity and determine line loss for a segment, the total load on that segment must be determined. The total load for a segment (A_S) is the sum of all loads, in amps, from equipment located at or beyond the end of the segment farthest from the electrical service cabinet.

All Signal and ITS Cabinet loads are evaluated at 120 volts. Signal and ITS cabinets that are located a significant distance from the electrical service cabinet normally require a transformer with the cabinet. The transformer is supplied by a higher voltage circuit to allow for smaller wire over the longer distance.

Lighting and transformer supply circuits shall initially be evaluated at 240 volts, unless there is a special case justifying 120 volts for a lighting circuit. If the wire size for any lighting circuit exceeds #2 AWG, or any transformer supply circuit exceeds #2/0 AWG, then 480-volt circuits may be used for all circuits supplied from that electrical service cabinet. Note that only 480-volt circuits are available from a 480-volt service (Type E or Type C), requiring a separate transformer cabinet for any lower voltage loads.

Wire shall not be smaller than #8 AWG (copper) for all circuits and shall not be smaller than #6 AWG (copper) for any circuit powering a Traffic Signal or ITS cabinet, regardless of distance. #10 AWG (copper) wire may be considered for lighting circuits with approval from the Region Signal Maintenance Manager.

E1.3(1) Line Loss

Line loss shall be determined for all circuits and all branches of those circuits. Line loss is represented by a reduction in voltage V_d (voltage drop). Voltage drop is calculated for every segment of the circuit. Each run of conduit between openings, such as in a junction box or cabinet, is a segment. The voltage drop for the segment is calculated using the formula shown in Equation 3-1:

$$V_D = 2I_S L_S R_W \qquad \textit{Equation (3-1)}$$

Where:

- V_D = Voltage Drop for the segment, in volts.
- I_S = Total amp load (current) on that segment, in amps.
- L_S = Length of the segment, in feet. Length of the conduit segment path between outlets plus 10 feet. For aerial circuits, add 10% of the distance between poles to account for sag.
- R_W = Wire Resistance, in ohms/ft.

Wire resistance is dependent on the type and size of wire. For WSDOT systems, the values for copper and aluminum wire are listed in Table E1.3-1.

Table E1.3-1; WSDOT Wire Resistance (R_W) Values

Wire Size (AWG)	Cu Wire Resistance (ohms/ft)	Al Wire Resistance (ohms/ft)
14	0.0032600	N/A
12	0.0020500	N/A
10	0.0012900	N/A
8	0.0008090	0.0012800
6	0.0005100	0.0008080
4	0.0003210	0.0005080
2	0.0002010	0.0003190
1	0.0001600	0.0002530
1/0	0.0001270	0.0002010
2/0	0.0001010	0.0001590
3/0	0.0000797	0.0001260
4/0	0.0000626	0.0001260
250 kcmil	0.0000535	0.0001000
300 kcmil	0.0000446	0.0000847

Notes for Table E1.3-1:

1. Cu = Copper; Al = Aluminum
2. Resistance values are derived from NEC Chapter 9, Table 8, Conductor Properties. WSDOT uses values for coated copper for calculation purposes.

The maximum voltage drop for a circuit is limited to a certain percentage of the operating voltage, which varies depending on the type of circuit. The percentage voltage drop is the ratio of the voltage drop (V_D) to the supplied circuit voltage (V_{SYS}), expressed as a percentage. This conversion is shown in Equation E1.3-2. The maximum percentage voltage drop allowed for various circuit types is listed in Table E1.3-2.

$$\%V_D = \frac{V_D}{V_{SYS}}$$

Equation (E1.3-2)

Table E1.3-2; WSDOT Maximum Voltage Drop by Circuit Type

Circuit Type	Maximum Voltage Drop (V_D)
Supply to Signal or ITS Cabinet	3%
Supply to Transformer Cabinet	5%
New Illumination Circuit – Possible Future Expansion	5%
New Illumination Circuit – No Future Expansion	8%
Temporary Illumination Circuit (to be removed as part of project)	8%

E1.3(2) Ampacity

Although it is rarely an issue, the load for each segment must be verified against the ampacity of the wire for that segment. In the event that the load on a segment exceeds the ampacity of the wire for that segment, the wire size for that segment must be increased on that segment until it is greater than or equal to the segment load. Ampacity ratings for different wire types and sizes are shown in Table E1.3-3. Note that no more than four circuits (8 conductors) may be installed in a single conduit.

Table E1.3-3; WSDOT Wire Ampacity Values

Wire Size (AWG)	14	12	10	8	6	4	2	1	1/0	2/0	3/0	4/0	250 kcmil	300 kcmil
Cu Ampacity (A)	14	17.5	24.5	35	45.5	59.5	80.5	91	105	122.5	140	161	178.5	199.5
Al Ampacity (A)	N/A	N/A	N/A	28	35	45.5	63	70	84	94.5	108.5	126	143.5	161

Notes for Table E1.3-3:

1. Cu = Copper; Al = Aluminum.
2. Ampacities are derived from NEC Table 310.15(B)(16) for USE conductors (at 75°C), and modified using Table 310.15(B)(3)(a) for up to 9 current carrying conductors.

E1.3(3) Equipment Grounding Conductor

All conduits require an equipment grounding conductor, as described in Standard Specification 9-29.3(2)A3, regardless of the quantity or type of cables installed in the conduit (including empty conduits). The size of the grounding conductor is dependent on the circuit breaker protecting that circuit, when present. Due to the limited size of power circuits, WSDOT simplifies this by referencing the conductors in the conduit to determine the size of the ground conductor, as shown in Table E1.3-4. Aluminum ground conductors may only be used where aluminum wiring has been allowed.

Table E1.3-4; WSDOT Minimum Ground Conductor Sizes

Largest cable in conduit	Minimum Copper Ground Conductor Size (AWG)	Minimum Aluminum Ground Conductor Size (AWG)
Any Traffic Signal or ITS multi-conductor or fiber-optic cable; Power cables up to #1 AWG	#8	#6
Power cables from #1/0 AWG to 300 kcmil	#6	#4

Notes for Table E1.3-4: Ground conductor sizes based on NEC Table 250.122.

E1.4 Service and Transformer Cabinets

The type of service cabinet used depends on the required output voltages and the number of circuits. Table E1.4-1 shows the different WSDOT Electrical Service Cabinet Types and their available output circuits and voltages, as well as the circuit limitations for transformer cabinets.

Table E1.4-1; WSDOT Service and Transformer Cabinet Capacities

Service Cabinet Type	Available Voltage(s)	Total Single Breaker Positions (Note 1)	Available Single Breaker Positions (Note 2)	Maximum Double (2 Pole) Circuits (Note 3)	Maximum Lighting Circuits (Note 4)	Standard Plan Reference
Type A	120	2	2	N/A	1	J-10.16
Type B	120/240	10	8	4	4	J-10.17
Type B Modified	120/240	18	16	8	5	J-10.20
Type D	120/240	24	22	10	6	J-10.21
Type C	480	N/A	N/A	6	4	J-10.18
Type E	480	N/A	N/A	11	7	J-10.22
Transformer	120/240	6	6	4	N/A	J-10.25

Notes for Table E1.4-1:

1. Single positions are single pole (1-Pole or 1P) breaker positions for 120V circuits. Type C and Type E service cabinets do not directly support external 120V loads – an external transformer is required.
2. Single positions in some cabinets are pre-assigned for internal loads.
3. Double positions are double pole (2-Pole or 2P) breaker positions for either 240V or 480V circuits, depending on the cabinet type. For Type C and Type E service cabinets, one position is used for the internal transformer.
4. The number of lighting circuits available is limited to the number of lighting contactors that will physically fit in the cabinet. Each lighting circuit requires its own contactor.

E1.4(1) Circuit Breakers and Contactors

Circuit breakers and contactors are determined from the total load, in amps, of the connected circuit. To simplify calculations, WSDOT requires that lighting circuit breakers be sized at 140% of the total circuit load, and all other breakers be sized at 125% of the total circuit load. Circuit breakers are only available in the following industry standard sizes (in Amps):

- 15
- 20
- 30
- 40
- 50
- 60
- 70
- 80
- 90
- 100
- 125
- 150
- 175
- 200
- 225
- 250

Larger breakers do exist, but they exceed WSDOT restrictions on service and circuit size. The selected circuit breaker shall be rated equal to or greater than the calculated breaker size required.

Table E1.4-2 lists standard circuits and breaker sizes found in electrical service cabinets (amperages are rounded up slightly).

Table E1.4-2; WSDOT Standard Service Cabinet Circuits and Breaker Sizes

Load	Watts	Voltage	Amps	Breaker
Photocontrol	1	120	0.01	1P-15A
GFCI	1800	120	15	1P-20A
Heater	100	120	0.83	1P-15A
Internal Transformer	3000	480	6.25	2P-15A

Contactors are only used in lighting circuits. As with circuit breakers, these have limited standard sizes and are only available in 30-, 60- and 100-amp sizes. The contactor amp rating shall be equal to or greater than the total lighting circuit load. The selected circuit breaker should also be checked against the ampacity of the connected circuit wire, as it must be the smallest standard size to support the rated ampacity of the wire.

E1.4(2) Main Breakers and Utility Connections

Main circuit breaker and utility connection wiring (service conductors) are determined from the total cabinet load, in amps, required from the serving utility. The total cabinet load is the sum of all external and internal cabinet loads. The total internal cabinet load depends on the type of cabinet. Table E1.4-3 lists these internal loads, and which cabinets they are present in.

Table E1.4-3; WSDOT Built-In Cabinet Loads

Load	Label	Voltage	Amps	Watts	Cabinets Present
Photocontrol	LTG CTRL	120	0.01	1	A, B, B Mod, D
GFCI	GFCI	120	15	1800	B, B Mod, D, XFMR
Heater	Heater	120	0.83	100	D
Internal Transformer	XFMR	480	6.25	3000	C, E

Type C and Type E cabinets include a photocontrol and GFCI circuit (the Type E also includes a heater circuit), but these are connected to the separate 120V panel supplied by the internal transformer.

After calculating the total cabinet load, the main circuit breaker is sized at 125% of the total cabinet load. This is to address all continuous and non-continuous loads, as well as allow for future capacity. The main breaker must also be a standard size, as listed in Table E1.4-2. Main breakers may not be smaller than 60 Amps, with the single exception of Type A services, which require a minimum 30 Amp main breaker.

The size of the service conductors is based on the selected rating of the main breaker. The service conductor is selected such that it can carry the full amperage rating of the main breaker. Table E1.4-4 shows the appropriate wire size for each main breaker size and serving voltage type. Aluminum is only used for aerial service connections (aluminum triplex). Unless allowed by the serving utility, the riser from the metering point to the aerial connection point at the top of the pole shall be copper.

Table E1.4-4; WSDOT Minimum Service Conductor Sizes for Single Phase Services

Main Breaker Size (Amps)	30	40	50	60	70	80	90	100	125	150	175	200	225	250
Cu Service Conductor Size (AWG)	8	8	8	6	6	4	4	3	2	1/0	2/0	3/0	3/0	4/0
Al Service Conductor Size (AWG)	6	6	6	4	4	3	2	2	1/0	2/0	3/0	4/0	250 kcmil	300 kcmil

Notes for Table E1.4-4:

1. Cu = Copper; Al = Aluminum.
2. Sizes derived from the ampacities listed in NEC Table 310.15(B)(16) for USE-2 conductors.
3. Smallest allowable service conductor size is #8 AWG for copper and #6 AWG for aluminum.

When specifying the size of service conductors and any conduit supporting them, the wire note must read similar to the following example:

> "Install 2-inch conduit, riser, weather-head, and three #2 conductors unless otherwise directed by the serving utility."

Conduit size is determined as shown in Section E1.6. Include risers and weather-heads only for overhead service connections.

E1.4(3) Locating Service and Transformer Cabinets

If other cabinets are present, install the service cabinet on the same concrete pad if possible. Transformer cabinets shall always be installed on the same concrete pad as at least one of the cabinets that they supply. All cabinets require a minimum of 42 inches of clear, level space, comprised of either concrete pad or gravel (CSBC or similar) in front of all access doors. When a meter socket is required to be installed on the outside of the cabinet, 42 inches of clear, level space is required from the face of the installed meter. There must also be 42 inches of clear, level space along at least one side of the cabinet if there is access or a meter on multiple sides of the service cabinet.

For freeways and expressways, not including surface streets within limited access right of way or ramp terminals, a separate meter pedestal should be installed. The meter pedestal should be located such that it is accessible from a surface street outside of the highway right of way. This avoids the need for utility personnel to have to stop on the side of a freeway or expressway to access a meter or their service connection. If right of way fence is present, try to locate the meter pedestal just outside the right of way fence, but within WSDOT right of way. Otherwise, have a pocket or gate installed in the fence such that the meter pedestal is on the WSDOT side of the right of way line.

When a remote meter pedestal is used, size the conductors between the meter pedestal and the actual service cabinet based on the total load on the service cabinet and a maximum voltage drop of 1%. Calculate the voltage drop using the method shown in Section E1.3(1). The meter pedestal shall include a disconnect breaker in the customer (lower) portion of the pedestal that is the same size as the service cabinet main breaker. Maximum conductor size between a meter pedestal and a service cabinet is 500 kcmil. Larger wire or parallel runs of wire may not be used to meet voltage drop. If the connection between a service cabinet and a remote meter pedestal requires wire larger than 500 kcmil, the service will need to be relocated or split into two or more separate services instead.

E1.4(4) Electrical Service Agreements

Electrical service agreements establish service and billing for the electrical system supplied by a utility connection. In most cases the utility connection will have a meter, but there are some cases where an unmetered connection may be used – this is at the discretion of the serving utility.

E1.4(4)(a) Electrical Service Agreement Numbers

Each metered connection for WSDOT has a service agreement number assigned by the Region Utilities Office. Service agreement numbers use a 6 or 7 character code:

S	?	?*	#	#	#	#

The first three characters are letters:

- S; the first character is always S, for Service
- The second character denotes the WSDOT region:
    - A: Northwest
    - B: North Central
    - C: Olympic
    - D: Southwest
    - E: South Central
    - G: Eastern
    - U: Certain areas of the Seattle Metro Area (Northwest Region only)
- The third character denotes the WSDOT Region Maintenance Area (*not all regions include this character) or special use:
    - A: Area 1
    - B: Area 2
    - C: Area 3
    - D: Area 4
    - E: Area 5
    - X: Temporary; may be used for services installed and removed on the same contract, or for services that will be transferred to another owner (typically a City) upon project completion.

The last four characters are the up to four-digit service agreement number. Older services still in operation may have fewer than four digits.

Temporary services are still assigned the WSDOT region letter code for the second digit.

Examples:

- SUA 9999: Service agreement 9999, WSDOT Northwest region, urban corridors area, maintenance area 1.
- SBX 9999: Temporary service agreement 9999, WSDOT North Central region.

Existing services should continue use of the existing service agreement number, even if the service is being replaced in its entirety, as it maintains the maintenance record and accounting history for the location. These are recorded as modifications to existing service agreements.

For new electrical service connections, request a new number from the Region Utilities Office. They will need the basic service information described in Section E1.4(4)b to generate the new number and record.

E1.4(4)(b) Basic Service Agreement Information

The WSDOT Region Utilities Office and the serving electrical utility both need basic information about the service connection and the loads connected to it. The Electrical Utility Service Agreement Data Sheet provides information needed by both the Region Utilities Office and the serving utility, and the information is used to fill out any application forms that may be required by the utility.

Exhibit E1.4-1: Sample Electrical Utility Service Agreement Data Sheet

Washington State Department of Transportation

Electrical Utility Service Agreement Data Sheet

This form provides basic information for the WSDOT Region Utilities Office and the Serving Electrical Utility for one electrical service connection and the equipment being supported by that connection. The information on this form can normally be used to support completion of Utility

Location Information

1	WSDOT Service Agreement #:	SB 0246
2	Service Request Type:	New Service Connection
3	Connection Type:	Aerial (Overhead)
4	State Route:	Interstate 90
5	Service Location:	Interstate 90 EB Off-Ramp at Road O NE
6	Nearest Searchable Address:	396 Road O NE, Moses Lake, WA 98837 (Bing Maps)
7	Approximate SRMP:	182.87
8	Serving Utility:	Grant County PUD #2
9	Existing Utility Account Number:	##########

Service Cabinet Information

10	Service Voltage:	120V/240V Single Phase
11	Service Demand Load (kVA):	5
12	Service Panel Type:	WSDOT Modified Type B
13	Service Main Breaker Size (Amps):	20

Proposed Service Connection Wiring

14	Wire Size:	#6
15	Wire Type	Copper, USE/USE-2
16	Number of Conductors:	3

Additional Site Information

17	Equipment Served:	[X] Roadway Lighting [ ] Traffic Signal(s) [ ] Intelligent Transportation System(s) [ ] Other:
18	Requested Point of Service:	Existing overhead transformer #????? on pole #???????.
19	Description:	WSDOT is removing and replacing the existing service cabinet. Request disconnect from existing service cabinet and connection to new replacement service cabinet.
20	Special Instructions:	None

See WSDOT Roadside Electrical and Electronic Systems Standard E1, Roadside Power Distribution, for form instructions.

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The Electrical Utility Service Agreement Data Sheet is available from https://wsdot.wa.gov/engineering-standards/design-topics/traffic-illumination-traffic-signals-and-intelligent-transportation-systems-its, under the Tools, templates, and links tab.

Instructions for completing the Electrical Utility Service Agreement Data Sheet, by item number:

1. Enter the WSDOT Service Agreement number. Existing services should use the existing service agreement number. New service agreement numbers (including temporary service agreement numbers) are assigned by the Region Utility Office.

2. Service Request Type. Select one of the following types from the drop-down list:
   - New Service Connection. This is used where no service connection currently exists.
   - Disconnect/Reconnect. This is used where there is an existing service connection that needs to be temporarily disconnected to make changes or replace the service cabinet.
   - Customer Load Increase. This is used where additional load will be added to an existing service cabinet. This is necessary to ensure that the utility transformer supplying the service and the service connection wiring can support the increased load.
   - Disconnect and Removal. This is used where a service cabinet is being removed and not replaced. This allows for any necessary payments to the utility for removal and closeout of the existing agreement.

3. Connection Type. Select one of the following from the drop-down list:
   - Underground. The service connection uses underground conduit to either a pad or vault transformer, or to a riser on a utility pole with a pole mounted transformer.
   - Aerial (Overhead). Only used when service connection goes up a customer owned pole and is connected by aerial wiring to the utility pole.

4. State Route. Enter the state route using either “Interstate” or “Highway” and the number (do not use SR or State Route).

5. Service Location. Provide a basic description of the service location. Examples:
   - Intersection of Highway 999 and Center St.
   - Interstate 979 SB on-ramp at Meridian Ave.
   - EB shoulder of Highway 888 near milepost 676.28.

6. Nearest Searchable Address. Some utilities now require a physical postal type address for the service location, even though there is not a building or similar structure at the location. Provide an address that will show the location through at least one mapping service (such as Google™, Bing™, etc.). If the address will only search properly through one particular mapping service, identify that service. It must also be verified that the address provided is not an existing building or location.

7. Approximate SRMP. Provide the SRMP to the nearest 0.01 miles. For intersections and ramp terminals, use the closest SRMP of the mainline roadway perpendicular to the service location.

8. Serving Utility. Select the serving utility from the drop-down list. If the serving utility is not listed, the user can scroll down below the form fields to find the list of utilities. There is an empty spot available for a user-entered utility name, which can then be selected from the drop-down list.

9. Existing utility account number. When working with an existing service agreement, enter the existing utility account number for that location. Utilities do not normally track service agreements by WSDOT Service Agreement number, so this helps them to locate the existing account. For new service agreements, enter N/A.

10. Service Voltage. Select the service voltage type from the drop-down list:
    - 120/240V Single Phase. This is standard for all service cabinets except Type C and Type E.
    - 480V Single Phase. This is standard for Type C and Type E service cabinets.
    - 480V/277V Three Phase. This is a special case for Type C, Type E, or custom service cabinets. This is normally only used for special bridge and tunnel electrical systems.

11. Service Demand Load. Enter the peak load calculated for the service cabinet, in kVA.

12. Service Panel Type. Select the appropriate service panel type from the drop-down list:
    - Temporary Commercial. This may be used for temporary systems that will be installed and removed during the same project. This allows the contractor to use an appropriately rated off-the-shelf commercial panel instead of a WSDOT standard service cabinet for temporary electrical systems, which are generally cheaper and easier to obtain. This is allowed because WSDOT will never be responsible for maintaining the panel.
    - WSDOT Type A.
    - WSDOT Type B.
    - WSDOT Type B Modified.
    - WSDOT Type C.
    - WSDOT Type D.
    - WSDOT Type E.

13. Service Main Breaker Size (Amps). Select the current rating of the main breaker from the drop-down list. Does not include the number of poles (example: will show 60 instead of 2P-60).

14. Service connection wire size. The wire size for the service connection will be calculated automatically based on the size of the service main breaker (Item 13) in accordance with NEC Table 310.16. The serving utility may require something different, so this is shown as “proposed”. The cell can also accept a user entered wire size if it is different from calculated and known ahead of time.

15. Wire Type. Select the type of wire from the drop-down list:
    - Copper, USE/USE-2. Standard wire type for underground installations. Also used for aerial connections where the utility will provide the aerial wiring to the customer pole.
    - Aluminum Triplex. Standard wire type for aerial connections where the customer is required to provide the aerial wire.
    - Aluminum, USE/USE-2. Used in place of Copper USE/USE-2 wire where directed by the utility, or when directed by the Region Signal Maintenance Manager due to risk of wire theft.
16. Number of conductors. Enter the number of conductors for the service connection. This will almost always be three (two phase wires and a neutral wire) unless otherwise directed by the utility or connecting a 3-phase service.
17. Equipment Served. Enter an "X" in any of the applicable equipment type boxes:
    - Roadway Lighting. Includes any lighting circuit for roadways, pathways, etc.
    - Traffic Signal(s).
    - Intelligent Transportation System(s). Includes all ITS equipment, tolling equipment, etc.
    - Other. Provide a description for other loads that may be connected such as:
        - Flashing beacon systems, including rectangular rapid flashing beacon (RRFB) systems.
        - Tunnel operations and safety systems.
        - Bridge operations systems.
        - Pumps, motors, etc.
18. Requested point of service. Provide the utility identification number of the pole and/or transformer proposed as the point of service connection. For new service connections, the pole or vault may not have an existing transformer.
19. Description. Provide a basic description of the service cabinet related work and what is needed from the utility. Examples:
    - WSDOT is installing a new Type B Modified service cabinet – requesting new service connection. WSDOT will install new conduit, conductors, and pole riser in accordance with utility requirements.
    - WSDOT is replacing an existing Type E service cabinet. Requesting disconnection of existing service cabinet and new service connection to new service cabinet. WSDOT will install conduit and conductors in accordance with utility requirements.
20. Special Instruction. Include any special or unusual instructions that may be required to complete the service connection, such as more substantial modifications needed to the utility distribution system or stricter than normal requirements.

Once the form is completed, print a PDF copy (the grey informational portion should not print) and provide the Electrical Utility Service Agreement Data Sheet with the request to the WSDOT Region Utilities Office. For Design-Builders, provide a copy of this data sheet to WSDOT for any service agreement that will be transferred to WSDOT as part of the project.

E1.4(4)(c) Utility Applications

When a utility requires an application form to be completed, some additional information may be necessary. The following items may be requested or required as part of the application form:

- Project information. This will be general information for the overall project. It is recommended to include the WSDOT contract number so that the form can be tracked more easily.
- Billing information. Confirm with the Region Signal Maintenance Office the appropriate billing point of contact at WSDOT. This varies by region.
- Project contact. This will normally be a designated person working for the electrical contractor/subcontractor, but could be a contact with the prime contractor or other member of a Design-Build team. When forms are completed before contract ad and award, this may be a designated person in the WSDOT Construction Project Office.
- Building information. Since WSDOT services are typically not buildings, most building information is N/A. However, this is where the nearest searchable address may be needed for the service location information.
- Number of runs. This is typically referring to how many sets of service conductors are being installed. This will almost always be only one.
- Load information. Many utilities request a breakdown of load types. If there is a list of typical load types, loads are normally listed as follows:
    - Lighting: All lighting types (roadway, pathway, etc.)
    - Miscellaneous: All other standard load types (internal service cabinet loads, traffic signals, ITS, beacons, etc.)
    - Motors/Other Motors: This may be used where pumps or motors are connected to a service. Only pumps and motors will include starting current and horsepower (HP) – contact the WSDOT HQ Traffic Office for assistance.
- Moving existing facilities. This is normally only included if utility relocation is required as part of the service agreement.

Although the designer can complete the application form, the application may only be signed by the WSDOT Region Utilities Engineer or the designated member of the Design-Build team (for Design-Build projects only).

E1.5 Conduit

E1.5(1) Wire and Conduit Routing

WSDOT systems allow for a certain amount of overlap for wiring within a conduit and junction box system. However, there are certain restrictions on how conduits may be shared:

- Conduit may not be shared between wire, of any type, powered from one electrical service or transformer cabinet and wire powered from a different electrical service or transformer cabinet. This includes wiring powered by a transformer cabinet and wiring powered by the electrical service cabinet powering that transformer cabinet. WSDOT considers each electrical service cabinet and transformer cabinet an independent power source.
- Power conductors may not be installed in the same conduit as Traffic Signal or ITS cables, unless approved by the Region Signal Maintenance Manager. Power conductors are any conductor supplying power from a service or transformer cabinet to a downstream load (such as lighting or a cabinet).
- For new installations, no more than four power circuits may be installed in one conduit.
- For new installations, it is recommended that lighting circuits be installed in conduits separate from cabinet and transformer power circuits.

Conduits should be placed close to the roadway shoulder where trenching can be used to install the conduit. Conduit should generally parallel the edge of the roadway or similar geographic features, as installation is typically easier than trying to install straight runs between points – particularly when the space between junction boxes is anything other than flat, open ground (grass, dirt, or similar bare ground).

E1.5(2) Conduit Sizing

Conduit sizes are determined from the amount of cross-sectional area will be occupied in the conduit by wiring. For WSDOT systems, the conduit capacities shown in Table E1.5-1 and the wire areas in Table E1.5-2 are used to accommodate all allowable conduit types. Table E1.5-2 only shows single, current carrying conductors; for other wire types, see Traffic Signal and ITS specific guidance.

Table E1.5-1; WSDOT Conduit Capacities

Conduit Size (in)	26% fill (in^2)	40% fill (in^2)	Total Area (100% fill) (in^2)	Metric Size (Note 2)
1/2 (Note 3)	*0.056*	*0.087*	*0.217*	*16*
1	0.179	0.275	0.688	27
1 1/4 Note 3	*0.322*	*0.495*	*1.237*	*35*
1 1/2 (Note 3)	*0.445*	*0.684*	*1.711*	*41*
2	0.747	1.150	2.874	53
3	1.675	2.577	6.442	78
4	2.927	4.503	11.258	103
5	4.642	7.142	17.855	129
6	6.655	10.239	25.598	155

Notes for Table E1.5-1:

1. Capacities based on Schedule 80 PVC conduit, as shown in NEC Chapter 9, Table 4.
2. Metric Size shown for reference only for metric as-built plans.
3. Special case sizes. May only be used to modify an existing conduit run or with special permission.

Table E1.5-2; Single Conductor Wire (USE-2) Cross-Sectional Areas

Wire Size (AWG)	14	12	10	8	6	4	2	1	1/0	2/0	3/0	4/0	250 kcmil	300 kcmil
Area (in^2)	0.023	0.029	0.035	0.062	0.081	0.108	0.146	0.197	0.229	0.274	0.322	0.385	0.478	0.555

Notes for Table E1.5-2: Areas based on manufacturer specification sheets for USE-2 wire.

The maximum conduit fill percentage is dependent on the type of installation:

- Existing conduit, with or without existing wire: 40%. Based on NEC Chapter 9, Table 1, for more than two cables.
- New conduit: 26%. Allows for additional future cables.

WSDOT assumes that all conduits will have more than two conductors at some point. The sum of the cross-sectional areas of all installed cables must be less than or equal to the area allowed by the applicable fill percentage. Equation E1.5-1 demonstrates this comparison. Do not forget to include the ground conductor.

$$Q_1A_1 + Q_2A_2 + \cdots + Q_nA_n \leq A_{CF} \qquad \textit{Equation (E1.5-1)}$$

Where:

- Q_n = Quantity of conductor type "n".
- A_n = Cross-sectional area of conductor type "n", per Table E1.5-2, in square inches.
- A_{CF} = Allowable conduit fill area, per Table E1.5-1, in square inches.

All new conduits shall be either 2-inch, 3-inch, or 4-inch diameter conduit, with the following exceptions:

- 1-inch conduit shall be used between a light standard foundation and its serving junction box.
- 1-inch conduit shall be used between a surface mounted luminaire (wall or ceiling, including suspended) and its serving junction box or hand hole.
- 1/2-inch, 1 1/4-inch, and 1 1/2-inch conduit may only be used to extend or modify an existing conduit run of that size.
- 5-inch and 6-inch conduit may be used under special circumstances with approval from the Region Signal Maintenance Manager.
- See Traffic Signal and ITS specific guidance for special cases for those types of systems.

Standard conduit types are Schedule 80 PVC, Schedule 80 HDPE, or Rigid Metal (RMC), and do not need to be specified in the Contract, as their use is dictated by Standard Specification 8-20.3(5)B. Liquid-Tight Flexible Metal Conduit (LFMC) is allowed in special cases, such as the last conduit segment connecting to a surface mounted luminaire or as a special type of expansion/deflection fitting. Specifying LFMC requires the approval of the Region Signal Maintenance Manager.

Empty spare conduits, or the equivalent empty space in occupied conduits, are required to be installed under the following circumstances:

- Any new conduit road crossing: minimum 2” spare conduit, connected to junction boxes on either side of the roadway. This does not include driveways.
- Any new service cabinet: minimum 2” spare conduit into service cabinet, connected to a junction box outside the cabinet pad.
- Any new transformer cabinet: minimum 2” spare conduit into load side of cabinet, connected to a junction box outside of the cabinet pad.
- See Traffic Signal and ITS specific guidance for additional spare conduit requirements for those types of systems.

Equivalent empty space means empty space equivalent to the 40% fill area of an empty conduit of the required size. Spare conduits must be shown in the Contract Plans.

E1.5(3) Conduit In or On Structures

Installing conduits in or on structures requires coordination with the structure designer. All conduits installed on or in structures are 2-inch diameter conduits, with the exception of 1-inch conduits connecting to luminaires (or their supports) and ITS outerduct (see ITS specific guidance for more details).

On new construction, all cast in place barrier for bridge rails or walls shall include two, 2-inch conduits installed in the barrier, regardless of their use – both may be empty. Each conduit run shall be fully isolated from any other, including its own junction boxes both on and off the structure. A third conduit may be installed within a barrier, but a note must be added requiring that the conduits be tied such that they are stacked vertically in the barrier. No more than three conduits may be installed in a barrier, not including 1-inch branches to luminaires or other equipment. Ensure that the structure designer knows how many conduits are being installed in each barrier.

Conduits may only be installed on the outside of existing structures with the approval of the WSDOT Bridge and Structures office. Example of locations where conduit is surface mounted include the outside of a bridge face, across a bridge pier crossbeam, or up a bridge pier column. These should be limited to the maximum extent necessary for the system to work. Transitions from columns to crossbeams or from crossbeams to the bridge itself are required to be LFMC. Conduit bodies may be necessary to provide pull points on either side of the LFMC segment. Sharp conduit corners on structures are the only other location where conduit bodies may be considered for conduit runs.

E1.6 Junction Boxes and Vaults

Junction boxes and vaults provide access to and accommodate changes in direction of conduits and wiring. Junction boxes include Type 1, 2, 4, 5, 6, and 8 junction boxes and structure mounted NEMA boxes. Vaults include pull boxes, small cable vaults, and cable vaults. For power circuits, the only approved vault type is a pull box.

E1.6(1) Box and Vault Spacing

Junction box spacing is dependent upon the geometry of the conduit run and the types of boxes and/or equipment being connected:

- A box or vault is required within 10 feet (5 feet is preferable) of any light standard, traffic signal standard, or sign structure.
- A box or vault is required within 5 feet of any cabinet (includes service, transformer, traffic signal, and ITS cabinets)
- A box or vault is required in the ground within 10 feet of a transition to/from a barrier (bridge barrier, cast in place barrier, etc.).
- Within traffic barrier (bridge or otherwise):
    - Where the length of the traffic barrier with conduit is 100 feet or less, a structure mounted junction box (NEMA box) is not required, and the conduit may be continuous between the two off-structure ground boxes (includes required expansion and deflection fittings).
    - Where the length of the traffic barrier with conduit is more than 100 feet up to 200 feet, only one NEMA box is required in the traffic barrier for each conduit. NEMA boxes should be placed roughly centered in the barrier

- Where the length of the traffic barrier with conduit is more than 200 feet, each conduit run shall include NEMA boxes spaced no more than 200 feet apart. Spacing may be adjusted to center boxes between actual or dummy joints in the traffic barrier.

- Where there are no more than 30 degrees of bends in the conduit run, not including 90 degree sweeps into the junction boxes, in-ground and surface mounted junction boxes may be spaced up to 300 feet apart. This also applies to conduit runs connecting a junction box to a vault.
- Where there are more than 30 degrees of bends in a conduit run, not including 90 degree sweeps into the junction boxes, junction boxes may be spaced up to 200 feet apart.
- Spacing between two vaults may be up to 750 feet where the conduit does not include more than 90° of bends (there are no end sweeps for conduit entering vaults).
- 1000 foot spacing between vaults may not be used for any conduit containing current carrying conductors of any type. 1000 foot spacing may only be used for conduits containing only fiber-optic cable (for this purpose, the included ground/locate wire is not considered a current carrying conductor).

Additional junction boxes are required if a conduit run will exceed 360° of bends between outlets. For conduit installed in the ground, 180° of bends are normally taken up by the 90° bends up into the box or cabinet at each end, limiting any additional horizontal of vertical bends to 180°.

E1.6(2) Ground Installed Boxes and Vaults

Junction boxes installed in the ground should be located outside of the shoulder of the roadway, outside of any paved surface. In locations with sidewalk, junction boxes should be located outside of the sidewalk if possible. Junction boxes may not be placed in the bottom of a ditch and must be located between the edge of the paved road surface and the ditch flow line, as close to the paved road surface as possible. Do not install a box in an active traffic lane unless absolutely necessary and approved by the Region Signal Maintenance Manager.

Table E1.6-1 shows the six standard types of junction boxes for ground installations, and the conduit capacities for each (including pull boxes).

Table E1.6-1; WSDOT Ground Junction Boxes

Box Type	Standard Plan Reference	Maximum conduit allowance (inches)
Type 1	J-40.10	6
Type 2	J-40.10	12
Type 4	J-40.20	6
Type 5	J-40.20	12
Type 6	J-40.20	24
Type 8	J-40.30	24
Pull Box	J-90.10	40

The maximum allowed conduit is the limit of the sum of the diameters of all conduits entering the junction box. If the sum of the diameters of all conduits entering the box exceeds the maximum allowed conduit rating, then a larger box or multiple boxes must be used. Use the smallest junction box necessary for the total diameter of conduits entering the box.

Type 4, Type 5, and Type 6 junction boxes are heavy-duty (HD) versions of the Type 1, Type 2, and Type 8 boxes, respectively. HD boxes are required where the box will be within a paved surface, such as a roadway lane or shoulder, or a commercial driveway. HD boxes should be considered for other locations where it is likely that larger trucks will be driving over the box, such as a driveway to a gravel pit or similar construction or material site.

Pull boxes may be used for long power runs or where multiple boxes may not be an option to support many conduits. Where pull boxes are being considered, surrounding grade is more critical as pull boxes cannot be readily placed in slopes and require additional grading if any part of the box will extend more than four inches above grade. Pull boxes are available as either standard or heavy-duty – heavy-duty boxes are required in the same locations as HD junction boxes.

Where a box will be installed in a sidewalk, including sidewalk crossing a driveway or similar vehicle access, boxes with slip-resistant surfacing are required and should be called out in the Contract to increase awareness. Slip-resistant lids and frames are mandatory per Standard Specification 8-20.3(6), but this is sometimes overlooked on projects where there are only a few boxes requiring slip-resistance. Adding a note in the Contract is a simple way to avert any potential issues.

E1.6(3) Structure Mounted Boxes

Structure mounted junction boxes are stainless steel junction boxes, rated NEMA 3R (weather-resistant) or 4X (watertight), and commonly referred to as just "NEMA boxes". WSDOT has three basic types of NEMA boxes: in-barrier mounted, surface mounted, and in-deck mounted. When viewing a structure mounted junction box, as viewed from the opening (lid), the distance from the lid to the back of the box is the depth (D), the horizontal dimension is the width (W), and the vertical dimension is the height (H).

E1.6(3)(a) In-Barrier Boxes

In-barrier boxes are fixed at an effective size (usable space) of 18" W x 8" H x 8" D. Conduits may only enter the left and right sides (ends) of the box – they may not enter the top, bottom, or back of the box. Each end can only support up to 4 inches of total conduit diameter, typically as either two 2-inch conduits or one 2-inch conduit with up to two 1-inch conduits. Although there are two types of in-barrier boxes – NEMA 3R Adjustable (Standard Plan J-40.37) and NEMA 4X Fixed (Standard Plan J-40.36) – they have the same capacity. Contractors determine which type based on the construction method used for the barrier. Plans should just reference "NEMA barrier box".

E1.6(3)(b) Surface Mounted and In-Deck Boxes

Surface mounted boxes are mounted to the surface of a structure, rather than being set into the structure. In-deck mounted boxes are similar to in-barrier boxes, except that they are embedded in the ground surface of the structure – typically sidewalk or other non-driving surface. These boxes are required to be sized based on the sizes of the conduit entering the box, and which faces of the box they are entering (NEC 314.28). Conduit may enter any face of these boxes except for the lid.

To keep sizing simple and to reduce the need for custom ordered boxes, WSDOT requires all surface mounted and in-deck box dimensions to be multiples of 2 inches (6”, 8”, 12”, 18”, etc.). No dimension may be smaller than 4 inches (this does not apply to one or two gang electrical boxes used for items like receptacles and light switches).

Boxes are sized to accommodate both the amount of conduit entering and the manipulation of the wiring passing through them. Each wall with conduit entering must be used to evaluate minimum dimensions. For a given wall, dimensions relative to that wall are determined as follows:

1. The distance to the wall opposite the wall being evaluated depends on where other conduits enter the box.

    a. Straight Pull: Conduits enter opposing ends of the box. The minimum distance to the opposite wall is 8 times the diameter of the largest conduit entering the wall being evaluated (equation E1.6-1). Use the largest diameter conduit of all conduits entering the two opposing walls, as the largest conduit will determine the distance between the two opposing walls being evaluated.

    b. Corner Pull or U Pull: Conduits do not enter opposing ends of the box. The minimum distance to the opposite wall is 6 times the diameter of the largest conduit entering the wall being evaluated, plus the sum of the diameters of all other conduits entering the wall being evaluated (Equation E1.6-2). WSDOT ignores splices and same conductor through-pulls when sizing boxes.

Straight Pull: $$L_{min} = (8 \times D_{MAX})$$ *Equation (E1.6-1)*

Corner or U Pull: $$L_{min} = (6 \times D_{MAX}) + (D_{C1} + D_{C2} + \cdots + D_{Cn})$$ *Equation (E1.6-2)*

Where:

- L_{min} = The minimum box wall length, for that dimension.
- D_{MAX} = Diameter of conduit largest conduit, in inches, in that row or column.
- D_{Cn} = Diameter of conduit “n”, in inches, in that row or column.

2. The dimensions of the wall being evaluated depend on the sizes and number of conduits entering that wall. WSDOT only allows a single row or column for standard installations, so there should only be one line of conduits in any wall. The axis of the row or column (axis with one or more conduits) is the long dimension, and the perpendicular axis (axis is always only one conduit) is the short dimension. The minimum size of that wall dimension is the sum of the conduit diameters along that axis, plus 1.5 times the number of conduits in that axis, and is shown in Equation E1.6-3.

$$L_{min} = (D_{C1} + D_{C2} + \cdots + D_{Cn}) + 1.5"Q_C \qquad \text{Equation (E1.6-3)}$$

Where:

- L_{min} = The minimum box wall length, for that dimension.
- D_{Cn} = Diameter of conduit "n", in inches, in that row or column.
- Q_C = The total quantity of conduits in that row or column of conduits.

Example:

A box wall has two 1-inch conduits and one 2-inch conduit in a single row, and no other factors control the dimensions of the wall where those conduits enter. The wall dimensions would be:

$$L_{min-long} = (1" + 1" + 2") + 1.5"(3) = 4" + 4.5" = 8.5"$$

$$L_{min-short} = 2" + 1.5"(1) = 2" + 1.5" = 3.5"$$

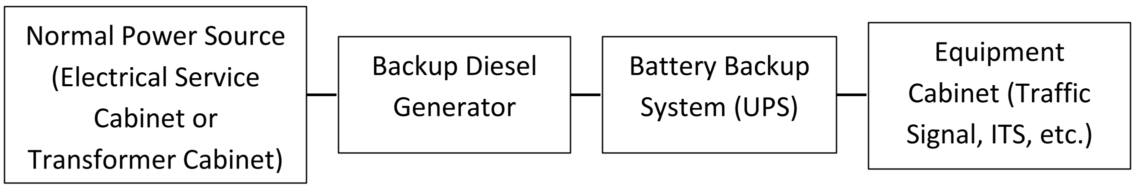
Rounding up to the nearest 2-inch increment, greater than or equal to 6, this particular wall's dimensions would be 10" by 6".

Repeat these calculations for each wall with conduit entering. The largest value calculated for each box dimension (height, width, and depth) are used for the overall box dimensions.

E1.7 Backup Power Supplies

Backup power supplies include diesel generators and battery backup systems (BBS or UPS – Uninterruptible Power Supplies). This section only discusses providing permanently installed backup power to a single cabinet requiring 120V power. For backup power to multiple cabinets or to loads requiring 240V or 480V, contact the Headquarters Traffic Office for assistance.

The Region Signal Maintenance Manager will determine if battery backup power, generator backup power, or both are required. Generally, a battery backup system will provide 8 hours of backup power, and a generator will provide up to 72 hours of backup power. When including backup power systems, these systems are connected in the following order:



If battery or generator backup power are not required, that block is omitted from the functional block diagram.

UPS systems are designed to support the basic loads of a traffic signal cabinet. Backup generators must be sized such that they can provide the total load of the protected cabinet, as determined in Section E1.2. Specify the minimum total load that must be supported by the generator in kilowatts (kW). Generator sizes vary between manufacturers, and this allows for selection of a standard generator from a particular manufacturer.

Although not shown in the block diagram above, the diesel generator will have an automatic transfer switch, typically in a separate cabinet or panel, where the electrical connections up and downstream are actually made.

When laying the equipment out on a cabinet pad, they should be placed in the same order as the block diagram to prevent having conduit runs passing back and forth beneath other cabinets to make the required connections.

E1.8 References

The following references are used in the development of this chapter:

E1.8(1) Laws and Regulations

National Electrical Code (NEC), NFPA, Quincy, MA

Revised Code of Washington (RCW) 19.28, Electricians and Electrical Installations

Washington Administrative Code (WAC) 296-46B, Electrical Safety Standards, Administration, and Installation

E1.8(2) Design Guidance

Design Manual, M 22-01, WSDOT

Standard Plans for Road, Bridge, and Municipal Construction, M 21-01, WSDOT

Standard Specifications for Road, Bridge, and Municipal Construction (Standard Specifications), M 41-10, WSDOT