Bonding and Grounding

NEC Articles
230, 250

Standard Specifications
• 8-20.3(9)
1. If parallel circuits of different sizes are contained in one conduit, the size of the grounding conductor shall be determined on the basis of the largest conductor. Only one grounding conductor is required for each conduit regardless of the number of circuits contained.

2. Service ground per serving utility requirement. If the utility uses aluminum service conductors, an approved Al-Cu pressure type ground connector shall be used to secure the service neutral to the copper neutral bar in the service enclosure. Except for the above, all grounding conductors shall be copper.

3. Equipment grounding conductors and grounding electrode conductors shall be sized in accordance with the National Electric Code (No. 8 minimum).
Ground Rod in Tile
Refer to J-3b for foundation installs
The Service Ground

• J-9A Key note 20: To Neutral Buss.
• 8-20.3(9): The first service ground rod shall be connected to a continuous ground electrode conductor running to the service neutral buss.
Ground Rod With 2 Clamps
Use SS Hardware to Bond JB Not Zinc Plated
Crimp Ground Wires to Braided Strap
Exothermal Weld Ground Ring
8-20.3(9) Grounding and Bonding

- All metallic appurtenances containing electrical conductors shall be made mechanically and electrically secure to form a continuous grounding system.
- Where conduit is installed the installation shall include an equipment grounding conductor in addition to the conductors noted in the contract.
- Where an existing conduit is used for new circuits an equipment grounding conductor shall be added unless already existing.
- The ground conductors shall be sized per the NEC to meet the grounding requirements of the largest current carrying conductors in the conduit. Minimum Size #8 WSDOT.
Services and Transformers

NEC Articles
210, 225, 230, 240, 250, T250.66, T250.122, 300, 312, 408, 450

Standard Specifications
- 8-20.3(10)
- 9-29.24 service cabinets
- 9-29.24(1) painting
- 9-29.24(2) electrical circuit breakers and contactors
Type “B” Service

J-3b
Type “B” Service
Type “D” Service
Inside the Type D Service
Inside 400 Amp Type D Service
Inside the Type “E” Service

J-3d
Common Problems

Label Busswork Rating:
- J-3b Key note 21
- J-3c Key note 25
- J-3d Key note 28

Power Conduit Should Extend Into Wireway

Tinned copper, Anti oxidant, Double nuts

| J-3d   | key note 15 |
More Problems

Plastic holder on door
Key Note 17 specifies:
“Metal Wiring Diagram Holder”

Phenolic Tag on bypass switch
General Note 5
Minimum Size Panel Boards

- **J-3b**  Type B Service
  Key Note 20 - 18 Circuit Panel Board

- **J-3c**  Type D Service
  Key 24 - 24 Circuit Panel Board

- **J-3d**  Type E Service
  Key 27 - 24 Circuit Panel Board

In this picture this is a 16 Circuit Panel board
Transformer and 120 V Cabinet
Conductors Too Large for Lugs

9-29.24 (B) If field wiring larger than that which the contactors or breakers will accommodate is required by the contract, a terminal board shall be supplied for use as a splicing block.

Pin connectors could be accepted with approval.
Field Test

Standard Specifications

- 8-20.3(11) Testing (Electrical)
- 8-20.3(14)D Induction Loops & Lead-in Cable
- 6-02.3(2)B Commercial concrete
- 6-02.3(5)A General acceptance of concrete
- 8-20.3(8)A Signal Controllers

NW Region Special Provisions

- 8-20.3 Com. Cable, Fiber, VMS, CCTV, Ramp Meters, & Hars
<table>
<thead>
<tr>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Power circuit testing 8-20.3(11).</td>
<td></td>
</tr>
<tr>
<td>2. Induction loops and lead-in cable test 8-20.3(14)D.</td>
<td></td>
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<tr>
<td>4. Signal Controller Testing 8-20.3(14)A.</td>
<td></td>
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<tr>
<td>5. Twisted-Pair (TWP) Copper Cable Testing as required in the ITS Special Provisions. S.P. 8-20.3.</td>
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<td>6. Fiber Optic Cable Testing.</td>
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<tr>
<td>a. Attenuation Testing</td>
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<tr>
<td>b. Optical Time Domain Reflectometer (OTDR) Testing, as required in the Special Provisions. S.P. 8-20.3</td>
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<td>7. Variable Message Signs.</td>
<td></td>
</tr>
<tr>
<td>a. System testing of the VMS Hardware.</td>
<td></td>
</tr>
<tr>
<td>b. NTCIP testing for the VMS sign.</td>
<td></td>
</tr>
<tr>
<td>c. Acceptance Testing of the VMS sign as required in the Special Provisions. S.P. 8-20.3</td>
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</tr>
<tr>
<td>a. CCTV Test.</td>
<td></td>
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<tr>
<td>b. Bench CCTV Test.</td>
<td></td>
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<tr>
<td>c. Local CCTV Test.</td>
<td></td>
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<tr>
<td>d. Hub CCTV Test.</td>
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<tr>
<td>e. TMC CCTV Test as required in the Special Provisions. S.P. 8-20.3</td>
<td></td>
</tr>
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<td>a. Cabinet testing.</td>
<td></td>
</tr>
<tr>
<td>b. Hardware and Systems Test.</td>
<td></td>
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<tr>
<td>c. Modem Testing.</td>
<td></td>
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<tr>
<td>d. Controller Testing.</td>
<td></td>
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<tr>
<td>e. Turn on Test as required in the Special Provisions. S.P. 8-20.3</td>
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<tr>
<td>10. HAR System Testing as required in the ITS Special Provisions. S.P. 8-20.3</td>
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Megometer
Field Test Illumination Circuits
**8-20.3(14)D Test for Induction Loops and Lead-in Cable**

<table>
<thead>
<tr>
<th>Loop Number</th>
<th>Loop Type 3, 3A, 3B</th>
<th>Ohms. &lt;= 10</th>
<th>Meg. Test Loop/Gr. &gt;= 100</th>
<th>M. Henry R1 &gt;= 75</th>
<th>R3 &gt;= 150</th>
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</tbody>
</table>

Test “A” for long ITS loops should not exceed the values calculated using the formula below:

**Resistance per 1000 ft of #14 AWG, **

\[ R = \frac{3.16 \text{ ohms}}{1000 \text{ ft}} \times \text{distance of lead-in cable (ft)} \]

\[ R = 3.16 \times \frac{\text{distance of lead-in cable (ft)}}{1000} \]
6-02.3(2)B Commercial Concrete

- Commercial concrete shall have a minimum compressive strength at 28-days of 3000-psi in accordance with WSDOT FOP for ASSHTO22.

- Commercial class concrete shall not be used for structural items such as:
  - Foundation for High Mast Lights
  - Foundations for Mast arm Signals
  - Foundations for Cantilever Signs
  - Foundations for Sign Bridges
6-02.3(5) A Concrete Acceptance

- Will be accepted based on conformance to the requirements for temperature, slump, air content for concrete placed above finished ground line and the specified compressive strength at 28-days for sublots as tested and determined by the Contracting Agency.
### NW Region Signal Cabinet Test Report

**NW Region Signal Division**  
**Electronics Shop**  
3700 9th Avenue South  
Seattle, Wa. 98134

<table>
<thead>
<tr>
<th>TEST</th>
<th>Completed</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Test conflict monitor.</td>
<td></td>
</tr>
<tr>
<td>2 Visually check cabinet for damage.</td>
<td></td>
</tr>
<tr>
<td>3 Check tightness of all connectors.</td>
<td></td>
</tr>
<tr>
<td>4 Visually check 120V AC input service.</td>
<td></td>
</tr>
<tr>
<td>5 Test fan.</td>
<td></td>
</tr>
<tr>
<td>6 Check for proper power distribution.</td>
<td></td>
</tr>
<tr>
<td>7 Test cabinet flash mode.</td>
<td></td>
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<tr>
<td>8 Test conflict flash mode.</td>
<td></td>
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<tr>
<td>9 Test watch dog flash mode.</td>
<td></td>
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<tr>
<td>10 Test all outputs.</td>
<td></td>
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<tr>
<td>11 Test all vehicle inputs.</td>
<td></td>
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<tr>
<td>12 Test all preemption inputs.</td>
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<tr>
<td>13 Test all pedestrian inputs.</td>
<td></td>
</tr>
<tr>
<td>14 Test all police panel switches for proper operation.</td>
<td></td>
</tr>
<tr>
<td>15 Operation of cabinet for a minimum of 48 hours without problems of failures.</td>
<td></td>
</tr>
<tr>
<td>16 Affix WSDOT TESTED sticker on inside top front cabinet door.</td>
<td></td>
</tr>
<tr>
<td>17 Place a copy of this completed form and conflict monitor test report in cabinet.</td>
<td></td>
</tr>
</tbody>
</table>

I certify this cabinet has met all the above tests and is ready for service.

Signature  
______________________________

Name  
______________________________
Illumination Systems

NEC Articles 110.21, 250, 300.19, 402, 410, 590

Standard Specifications

- 8-20.3(13)
- 8-20.3(13)a light standards
- 8-20.3(13)b luminaires
- 9-29.6 light and signal standards
- 9-29.6(1) steel light and signal standards
- 9-29.6(2) slip base hardware
- 9-29.6(4) welding
- 9-29.10 luminaires
Put Together
Slip Base

SP J-28.40
Slip base installation shall conform to the following:

1. The slip plane shall be free of obstructions such as protruding conduit or anchor bolts. The conduit, anchor bolts, and other obstructions shall terminate at a height below the elevation of the top of the slip plate.

2. Washers in the slip plane shall be placed between the slip plate and the keeper plate.

3. Anchor bolts shall extend through the top heavy-hex nut two full threads to the extent possible while conforming to the specified slip base clearance requirements. Anchor bolts shall be tightened by the Turn-Of-Nut Tightening Method in accordance with Sections 6-03.3(33) and 8-20.3(4).

4. Clamping bolts shall be tightened in accordance with Sections 6-03.3(33) and 8-20.3(4). The clamping bolts shall be tightened to the specified torque, plus or minus 2 percent, in two stages using an accurately calibrated torque wrench before erecting the light standard. Except as otherwise specified, the Contractor shall install 1 inch diameter clamping bolts in all slip bases to a torque of 95 foot-pounds. The Contractor shall tighten the 1 1/8 inch diameter clamping bolts of slip bases for 50 foot light standards with double 10 foot mast arms or greater to a torque to 104 foot-pounds.

5. The galvanized surfaces of the slip plates, the keeper plate and the luminaire base plate shall be smooth, without irregularities, to reduce friction and to prevent slackening of bolt tension due to flattening of the irregularities.

6. Anchor bolts damaged after the foundation concrete is placed shall not be repaired by bending or welding. The Contractor’s repair procedure is to be submitted to the Engineer for approval prior to making any repairs. The procedure is to include removing the damaged portion of the anchor bolt, cutting threads on the undamaged portion to remain, the installation of an approved threaded sleeve nut and stud, and repairing the foundation with epoxy concrete. Epoxy concrete shall meet the requirements of Section 9-26.3(1)B.

7. The grout pad shall not extend above the elevation of the bottom of the anchor plate.

8. Wiring for slip base installation shall conform to details in the Standard Plans.
Put Together Slip Base

- Anchor plate
- Keeper Plate
- Slip plate
- Note washer placement
- Cinch bolts
- Torque bolts
Using the Torque Wrench

- Should not be jerked or hit. A steady pressure should be used until it comes to the specified torque plus or minus 2%. 8-20.3(13)A
- Bolts should be “tightly tightened in 2 stages”. The bolts should be hit with a hammer after the first tightening, and then torque them again. This will help relieve any pressures other than the bolt torque. 8-20.3(13)A
- Torque the bolts with the pole on the ground “before erecting the Light Pole” 8-20.3(13)A
- Never be use a Torque Wrench to loosen bolts
- Using an extension with a torque wrench will diminish accuracy
Drill Pole, Galvicon and Bolt the Arm
Slip Base

OK

Bolts Too High No Plate Washer

SP J-28.40
Plate Washers Must Be Flat
Slip base installation shall conform to the following:

1. The slip plane shall be free of obstructions such as protruding conduit or anchor bolts. The conduit, anchor bolts, and other obstructions shall terminate at a height below the elevation of the top of the slip plate.

2. Washers in the slip plane shall be placed between the slip plate and the keeper plate.

3. Anchor bolts shall extend through the top heavy-hex nut two full threads to the extent possible while conforming to the specified slip base clearance requirements. Anchor bolts shall be tightened by the Turn-Of-Nut Tightening Method in accordance with Sections 6-03.3(33) and 8-20.3(4).

4. Clamping bolts shall be tightened in accordance with Sections 6-03.3(33) and 8-20.3(4). The clamping bolts shall be tightened to the specified torque, plus or minus 2 percent, in two stages using an accurately calibrated torque wrench before erecting the light standard. Except as otherwise specified, the Contractor shall install 1 inch diameter clamping bolts in all slip bases to a torque of 95 foot-pounds. The Contractor shall tighten the 1 1/8 inch diameter clamping bolts of slip bases for 50 foot light standards with double 10 foot mast arms or greater to a torque to 104 foot-pounds.

5. The galvanized surfaces of the slip plates, the keeper plate and the luminaire base plate shall be smooth, without irregularities, to reduce friction and to prevent slackening of bolt tension due to flattening of the irregularities.

6. Anchor bolts damaged after the foundation concrete is placed shall not be repaired by bending or welding. The Contractor’s repair procedure is to be submitted to the Engineer for approval prior to making any repairs. The procedure is to include removing the damaged portion of the anchor bolt, cutting threads on the undamaged portion to remain, the installation of an approved threaded sleeve nut and stud, and repairing the foundation with epoxy concrete. Epoxy concrete shall meet the requirements of Section 9-26.3(1)B.

7. The grout pad shall not extend above the elevation of the bottom of the anchor plate.

8. Wiring for slip base installation shall conform to details in the Standard Plans.
Base Needs Material
Base and JB Too Low
Foundation Too Low or Grade Too High
Looking Inside Pole at Conduit
Quick Disconnects

Fuse kit

Fuse holder apart

Pin kit apart

Together

9-29.7

Page 9-165,6
Buchanan Fuse Kits (Signal Maintenance)
Screw Together Fuse Kit
Fuse Kits Installed, Improper Wire Markers

8-20.3(8)
Break Away Couplings
Pole Skirt
Pole With Skirt in Place
Fixed Base Pole

SP J-28.30
Make sure tags on arms and poles match
Identify Pole With 3-inch Series “C” Block Numbers

1. Luminaire Number
2. Luminaire Wattage
3. Luminaire Voltage
4. Service Number

8-20.3(13)A
Page 8-87,88

SS 8-20.3(13)A
Numbers on Luminaire Pole
Some Regions Vary. NW Region Requires: Service and Pole Number
Inside the Luminaire
With Strain Relief Clamp
Ballast Power Door
With Installation Date

8-20.3(13)C
Page 8-88

7-17-03
BK
Prime
Street Light/Luminaire Pole Installation Checklist

• Provided in your book
Aerial and Temporary Systems

NEC Articles 110.21, 250, 300, 300.19, 396, 402, 410, 590

Standard Specifications

• 8-20.3(7)
• 8-20.3(13)a Light Standards
  – Minimum Pole burial depth
• 8-20.3(13)b Luminaires
• 9-29.4 Messenger cable fittings
• 9-29.5 Pole line hardware
• 9-29.6(3) Timber Light and Signal Standards
Temp Span used until Permanent is Ready.
Span System Parts
Johnny Ball Insulator With Guy Wraps Installed

Top

Bottom
Wood Poles, Drilling the Hole
10% of 40-foot pole = 4-feet + 2-feet = 6-feet buried
# Pole Class Dimensions

**Douglas Fir and Southern Pine**

<table>
<thead>
<tr>
<th>Pole Class</th>
<th>Class 1</th>
<th>Class 2</th>
<th>Class 3</th>
<th>Class 4</th>
<th>Class 5</th>
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<tbody>
<tr>
<td>Minimum circumference at top in inches</td>
<td>27</td>
<td>25</td>
<td>23</td>
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<table>
<thead>
<tr>
<th>Length of pole</th>
<th>Minimum circumference at 6 foot from butt in inches</th>
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<td>36.5 34.0 32.0 29.5 27.5</td>
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<tr>
<td>100</td>
<td>58.0 55.0 NA  NA  NA</td>
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</tbody>
</table>
Luminaire Mounted With Through Bolt
Wedge Clamp
To be used with Tri-Plex only
Two Temp Lts.
Required to supplement equipment grounding for luminaire standards with direct burial, aerial feeds, or where required in the plans.
High Mast and Under Deck Lighting

NEC Articles 110.21, 250, 300.19, 402, 410, 590

- Standard Specifications
- 8-20.3(4) Foundations
- 8-20.3(13)C Luminaires
- 9-29.10(3) High Mast Luminaires
- 9-29.10(4) Under Deck and Wall Mount Luminaires
100 Foot Pole With Fixture Lowered
High Mast Pole With Fixture Lowered
Lowered High Mast Fixture With Adjusting Blocks Installed
High Mast Locking Pin

Pin Indicator

Adjusting Mechanism

Used to adjust fixture so it hangs level and all pins hit locks simultaneously.
High Mast Fixture
Winch and Circuit Breakers
Under Deck Lights

9-29.10(4)
Page 9-171
Print Reading Questions

1. What is the service type?
2. What is the service agreement number?
3. How many luminaries and what are the wattages?
4. Is the service lateral underground or overhead?
5. What is Luminaire #2 stationing?
6. What is the conduit size and wire size between Luminaire #1 and #2?
7. What is Luminaire base type?
8. What is the offset to the foundation for Luminaire #3?
9. How is conduit run #3 to be installed?
10. What is the depth of foundation Luminaire #1?
11. How is the service lateral to be connected to serving utility?
12. What is the legend symbol for overhead power?
13. What is the location of this intersection?
14. The JB next to Luminaire #2 is what type?
15. List the conduits and their sizes that enter the Luminaire #2 JB.
16. How many inches of conduit are shown in JB above?
Print Reading Questions with Answers

1. What is the service type? . . . . . Type “B mod”
2. What is the service agreement number? . . SAC 5003
3. How many luminaries and what are the wattages? . 4 Luminaries and 400 watt
4. Is the service lateral underground or overhead? . Underground
5. What is Luminaire #2 stationing? . . . SR-92-39+37
6. What is the conduit size and wire size Wire schedule #2 11/2” and two #8s
   between Luminaire #1 and #2?
7. What is Luminaire base type?. . . . . Slip
8. What is the offset Lum #3?. . . 37.00 RT
9. How is conduit run #3 to be installed? . . . Construction note #6, directional bore
10. What is the depth of foundation Luminaire #1? . Construction note #4, 6’ 0”
11. How is the service lateral to be connected . . C. note #3, coordinate through Engineer
to serving utility?
12. What is the legend symbol for overhead power? . OP
13. What is the location of this intersection? . . . SR-92 & 99th Ave NE
14. The JB next to Luminaire # 2 is what type? . . . Type 2
15. List the conduits and their sizes that enter the 4 conduits, 1”, 1.5”, 2” & 3”
   Luminaire #2 JB.
16. How many inches of conduit are shown in JB above? 7.5 inches of conduit