Oregon Department of Transportation

Traffic Lighting Design Manual

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OREGON DEPARTMENT of TRANSPORTATION
HIGHWAY DIVISION
TECHNICAL SERVICES
TRAFFIC-ROADWAY SECTION
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TABLE OF CONTENTS

TABLE OF CONTENTS **1**

1.0 GENERAL **6**

2.0 ORGANIZATION **6**

3.0 ILLUMINANCE LEVEL **6**

3.1 REFERENCES 6

3.2 STANDARD 6

1.) Use illuminance method to meet required average maintained horizontal illuminance level with computer program analysis of horizontal and vertical alignment of roadway. *6*

2.) Illumination levels are increased at critical decision points of the roadway. *7*

3.) Check glare and veiling luminance at critical decision points of the roadways. Satisfy design requirements (maximum of max to average luminance is 30-40%). *7*

4.) Use vertical illuminance levels at railroad crossing and other critical points. *7*

3.3 OPTIONAL 7

1.) Luminance method-level – See references. *7*

2.) Average maintained luminance level – See references. *7*

4.0 LUMINAIRES AND BALLAST **7**

4.1 REFERENCES 7

4.2 STANDARD 7

1.) The "Cobrahead" style luminaire with drop lens (flat glass where applicable) and high-pressure sodium lamps (70 to 400 watts). *7*

2.) Pole spacing established by the luminaire's photometric performance, pole configuration and other parameters. (Mounting height, hang over etc.) *7*

3.) Select magnetic regulator or other more efficient type of ballasts to limit load currents and moderate the conductor sizes. *7*

4.) High-mast luminaire (400 to 1000 watt HPS). *8*

5.) Underpass luminaire on structure. *8*

6.) Bikeway and pedestrian paths: "Shoe box" style with HPS lamps, American Electric's "Series 53/54 and 153/154". *8*

7.) For lighting projects outside ODOT jurisdiction: Check with city, county and related utility company for their design requirements. Cities and counties do have their own preference on lighting design and luminaire type. *8*

4.3 OPTIONAL 8

1.) Value engineering is applied on other types of lighting and luminaire. They are subject to approval by the Oregon Department of Transportation Traffic Engineer. 8

5.0 POLES AND TOWERS 8

5.1 REFERENCES 9

5.2 STANDARD 9

1.) Galvanized steel poles with slip or fixed base. 9

2.) Galvanized steel towers for high mast (Department approval is required). 9

3.) For lighting outside ODOT jurisdiction: check with city, county and related utility company for their design requirements or preferences. 9

5.3 OPTIONAL 10

1.) Steel and aluminum poles from manufacturer's catalogs (for cities, counties and others who prefer them). 10

2.) Treated wood poles (when applicable). 10

3.) Concrete poles 10

4.) Fiberglass poles 10

5.) Check with jurisdictional engineer and/or project architect (subject to approval of the road authority). 10

6.) Value Engineering is applied on other types of equipment. They are subject to approval by the Oregon Department of Transportation. 10

6.0 POWER SUPPLY 10

6.1 STANDARD 10

1.) Underground electrical service. 10

2.) System voltage: 240/480 volts, single phase or 120/240 volts, single phase (for smaller projects). 10

3.) Coordinate the availability and location of power service with utility company through Region utility specialist. 10

4.) Check servicing utility company's charge for supplying power (Cost is considered as an anticipated item to projects). 10

6.2 OPTIONAL 10

1.) Overhead electrical service. 10

2.) 277/480 volts, three phase (for large projects). 10

3.) 240 or 480 volt, three phase for tunnel lighting system. 10

4.) Other system voltages (check availability, preference of city or county). 11

7.0 ENERGY DISTRIBUTION SYSTEM 11

7.1 REFERENCES 11

7.2 STANDARD 11

1.) Underground distribution system. 11

2.) Locate service and control cabinet in the central area of the system. Use moderate sizes conductors, conduit and junction boxes for distribution. 11

3.) Use simple and efficient layout of conduit and junction boxes and conductors. Minimize sizes of conductors (Min size is #10 AWG.) while satisfying codes and requirements. (Check costs of conduit, conductors, and junction boxes). 11

4.) Keep system voltage drop under 5% per NEC. 11

5.) Provide a concrete junction box near each illumination pole. Then provide a conduit sweep into the pole with smaller conductors. 11

6.) Provide bridge designers with detail(s) of distribution system(s) on bridges and other structures. 11

7.) Coordinate with bridge designers on all electrical and lighting equipment (either cast-in-concrete or attached) located in bridges and other structures. 11

8.) Control Cabinets. 12

9.) Provide separate circuit(s) for sign illumination, navigation lights and aviation lights. 12

10.) Permits are required for conduit on railroad right-of-way and such installation should be avoided due to expenses and time involved. 12

11.) Switching Control. 12

7.3 OPTIONAL 12

1.) Overhead distribution system. 12

2.) Design and construction of distribution system by others. 12

8.0 TEMPORARY LIGHTING 12

8.1 REFERENCES 12

8.2 STANDARD 13

1.) High-pressure sodium lamps. 13

2.) Average maintained horizontal illumination method utilizing computer analysis for horizontal and vertical alignment of roadway. 13

3.) Critical (decision points) areas of roadway = 13.0 lux (1.2 fc). 13

4.) Maintenance Factor = (Luminaire dirt depreciation factor) times (Lamp lumen depreciation factor). 13

8.3 OPTIONAL 14

1.) Other light source may be used when design concept is to match and blend in with existing roadway luminaires. 14

2.) Project area and scope is described by the state and design is done by the contractor. 14

9.0 PARTIAL INTERCHANGE LIGHTING 14

9.1 REFERENCES 14

9.2 STANDARDS 14

1.) On Ramps - Standard of two poles at merging sections. Ramps in developed urban or suburban areas and ramps with high truck traffic may need more coverage. Ramps with longer acceleration lanes or complex alignment may need more coverage. 14

2.) Off-Ramps - Standard of three poles to cover gore area. Ramps with complex alignment or roadside features may need additional coverage or pull through light. 14

3.) Ramp Terminals - Standard of two poles at the intersection. One pole may be sufficient in rural area or T shape intersections. A wide intersection with crosswalk or raised island and a crossroad with physical median controls or channelization may need more coverage. 14

10.0 UNDERPASS AND TUNNEL LIGHTING 15

10.1 REFERENCES 15

10.2 STANDARD 15

1.) Underpass illumination is not part of the standard coverage. Exceptions: pedestrian & bicycle facilities under structure; merge & diverge areas under structure; wide structures (70+ feet) may be considered. 15

2.) In areas of continuous lighting, the luminaires adjacent to the underpasses should be placed such that the need for supplemental underpass luminaires may be eliminated. 15

3.) High-pressure sodium lamps. 15

4.) Designer should conduct a research on tunnel and tunnel lighting and use engineering judgment on selecting luminaire types, sizes, locations, orientation, etc. 15

5.) Use least amount of equipment to meet lighting requirements. 15

6.) Existing lighting may be replaced with an upgraded system with light levels below RP-22 design levels if there is engineering and safety justification to do so. Replacement lighting may be designed so that illumination levels are approximately the same if there is a minimal crash history. 15

7.) The daytime entrance zone light level is dependent upon the brightness features within the motorist's view on the portal approach. Utilize 2-3 light level switching to provide proper amount of lighting according to different ambient lighting conditions. 15

11.0 SIGN LIGHTING 15

11.1 REFERENCES 16

11.2 STANDARD 16

1.) Metal Halide or Induction light type. 16

2.) Use separate circuit(s) for sign illumination and use common conduit with roadway illumination circuits where possible. 16

3.) No roadway illumination pole located within 20 m (70 feet) of lighted sign. 16

4.) Size the conductors to keep the circuits within voltage drop limit that is calculated with at least twice the amount of connected load (Signs are frequently enlarged or added). 16

5.) In the area prone to vandalism, provide polycarbonate shield for luminaire (example: Around sidewalk on bridge).....16

6.) Install a cabinet with appropriate circuit breakers on or near sign support for maintenance.....16

7.) Provide special provisions for sign illumination:.....16

12.0 AVIATION AND NAVIGATION LIGHTING 16

12.1 REFERENCES 16

12.2 STANDARD 17

1.) Navigation Lighting.....17

2.) Aviation lighting. 17

13.0 ADDITONAL SOURCES..... 17

GENERAL

The purpose of the *Traffic Lighting Design Manual is to assist in the lighting design of future construction and reconstruction projects on state highways. It is not intended that existing lighting systems be modified as a result of this manual.* For policy practices, please refer to the *Lighting Policy and Guidelines*.

This design manual draws from several sources, which are cited in each section. *And this manual will address items not included in the AASHTO Roadway lighting design guide (Oct. 2005) or provide clarification on included items.*

1.0 ORGANIZATION

Explain the layout of the design guidelines.

2.0 ILLUMINANCE LEVEL

Provide reasonable illumination levels on the roadway according to national standards (AASHTO, IES etc.).

2.1 References

Roadway Lighting Design Guide. American Association of State Highway and Transportation Officials (AASHTO), Washington D.C., 2005.

The IESNA Lighting Handbook. Illuminating Engineering Society of North America, New York, 2000.

2.2 Standard

1.) Use illuminance method to meet required average maintained horizontal illuminance level with computer program analysis of horizontal and vertical alignment of roadway.
    a) Provide average illuminance level in lux (fc) – See references.
    b) Check minimum point. (2 lux/0.2 fc)
    c) Check maximum point. (See d) 2))
    d) Check uniformity ratios.
        1) Average to minimum – See references.
        2) Maximum to minimum (10:1 or less).
    e) Uniformity of illumination and Mean deviation. (For engineering judgment)

2.) Illumination levels are increased at critical decision points of the roadway.
   a) Gore areas - 11 to 16 lux (1.0 to 1.5 fc).
   b) Weaving lanes - 9 to 11 lux (0.8 to 1.0 fc) average.
   c) Intersections (Sum of illuminance levels of the crossing roads, or up to 1.5 times of main street illuminance).
   d) Underpasses (Up to 1.5 times of roadway illuminance level).

3.) Check glare and veiling luminance at critical decision points of the roadways. Satisfy design requirements (maximum of max to average luminance is 30-40%).

4.) Use vertical illuminance levels at railroad crossing and other critical points.

2.3 Optional

1.) Luminance method-level – See references.

2.) Average maintained luminance level – See references.
   a) Uniformity of luminance (average to minimum).
   b) Veiling luminance ratio (maximum to average).

3.0 LUMINAIRES AND BALLAST

Use the least amount of equipment to meet the lighting requirements of the project.

3.1 References

Manufacturer's catalog

Manufacturer's representative

3.2 Standard

1.) The "Cobrahead" style luminaire with drop lens (flat glass where applicable) and high-pressure sodium lamps (70 to 400 watts).

2.) Pole spacing established by the luminaire's photometric performance, pole configuration and other parameters. (Mounting height, hang over etc.)

3.) Select magnetic regulator or other more efficient type of ballasts to limit load currents and moderate the conductor sizes.

4.) High-mast luminaire (400 to 1000 watt HPS).
   a) Cut-off type for control of trespass light.
   b) Open and ventilated type or enclosed and filtered type.

5.) Underpass luminaire on structure.
   a) Recessed into box girder: GE's "Conserva 400/150" with 70-100 watt HPS.
   b) On open beam or girder type structure: GE's "Conserva" with integral ballast on pendant mount, or cobra-head style mounted on bracket.
   c) Rigid frame, overcrossing bents: Wall mount type with glare shield. High pressure sodium (HPS) lamps.

6.) Bikeway and pedestrian paths: "Shoe box" style with HPS lamps, American Electric's "Series 53/54 and 153/154".
   a) Recommend 9.2 m (30 foot) mounting height (lower mounting heights subject to vandalism).
   b) For underpasses and tunnels, select vandal resistant type.
   c) Check with jurisdictional engineer and/or project architect (subject to approval of the road authority).

7.) For lighting projects outside ODOT jurisdiction: Check with city, county and related utility company for their design requirements. Cities and counties do have their own preference on lighting design and luminaire type.

3.3 Optional

1.) Value engineering is applied on other types of lighting and luminaire. They are subject to approval by the Oregon Department of Transportation Traffic Engineer.
   a) Provide summary of proposal.
   b) Include economic analysis for cost effectiveness (Installation, maintenance and energy consumption).

4.0 POLES AND TOWERS

Locations of poles and towers shall be chosen to provide traffic safety. Use ODOT approved poles and towers.

4.1 References

Project Special Provisions

ODOT Standard Drawings

ODOT Standard Specifications

Manufacturer's Catalogs

4.2 Standard

1.) Galvanized steel poles with slip or fixed base.
    a) Use 12.2 m (40 foot) mounting height for freeways, interchanges and other state highways. Arm length is typically 1.8 m to 4.6 m (6 to 15 feet).
    b) 9.2 m (30 foot) setback from edge of travel lane (where no barriers are installed) for freeways, interchanges and other state highways.
        1) Slip base steel poles should be installed within "clear zones" on freeways and expressways.
        2) Fixed base poles must meet "clear zone" requirements for all highways or be protected.
    c) Place poles 1.5 m (5 foot) behind face of barrier/guardrail with 1.8 m (6 foot) minimum luminaire arm (luminaire should be in front of barrier face).
    d) Other mounting heights may be used. Mounting height restrictions should be considered for:
        1) Highways in urban area.
        2) Controlling trespass light.
        3) Interference with the view of property owners (when poles located near property line between owners).
        4) Effecting greenhouses, mink farms, etc.
        5) Overhead conflict with utility lines or structure.
        6) Up to 50 foot mounting height can be used where required.

2.) Galvanized steel towers for high mast (Department approval is required).

3.) For lighting outside ODOT jurisdiction: check with city, county and related utility company for their design requirements or preferences.

4.3 Optional

1.) Steel and aluminum poles from manufacturer's catalogs (for cities, counties and others who prefer them).

2.) Treated wood poles (when applicable).

3.) Concrete poles

4.) Fiberglass poles

5.) Check with jurisdictional engineer and/or project architect (subject to approval of the road authority).

6.) Value Engineering is applied on other types of equipment. They are subject to approval by the Oregon Department of Transportation.
    a) Provide summary of proposal.
    b) Include economic analysis for cost effectiveness.

5.0 POWER SUPPLY

Propose utility company to supply power at the nearest possible location to the project site. Utility company may charge for extending their utility lines.

5.1 Standard

1.) Underground electrical service.

2.) System voltage: 240/480 volts, single phase or 120/240 volts, single phase (for smaller projects).

3.) Coordinate the availability and location of power service with utility company through Region utility specialist.

4.) Check servicing utility company's charge for supplying power (Cost is considered as an anticipated item to projects).

5.2 Optional

1.) Overhead electrical service.

2.) 277/480 volts, three phase (for large projects).

3.) 240 or 480 volt, three phase for tunnel lighting system.

a) To reduce flicker and stroboscopic effect.

b) To moderate load current.

4.) Other system voltages (check availability, preference of city or county).

6.0 ENERGY DISTRIBUTION SYSTEM

Provide safe electrical system for longevity and dependability.

6.1 References

National Electrical Code

National Electrical Safety Code

ODOT Standard Specifications

Project Special Provisions

Manufacturer's Catalogs

ODOT Standard Drawings

6.2 Standard

1.) Underground distribution system.

2.) Locate service and control cabinet in the central area of the system. Use moderate sizes conductors, conduit and junction boxes for distribution.

3.) Use simple and efficient layout of conduit and junction boxes and conductors. Minimize sizes of conductors (Min size is #10 AWG.) while satisfying codes and requirements. (Check costs of conduit, conductors, and junction boxes).

4.) Keep system voltage drop under 5% per NEC.

   a) 4% drop maximum on distribution system.

   b) 1% drop maximum between utility transformer and service cabinet.

5.) Provide a concrete junction box near each illumination pole. Then provide a conduit sweep into the pole with smaller conductors.

6.) Provide bridge designers with detail(s) of distribution system(s) on bridges and other structures.

7.) Coordinate with bridge designers on all electrical and lighting equipment (either cast-in-concrete or attached) located in bridges and other structures.

8.) Control Cabinets.

   a) Main circuit breaker must be rated 600 volts (except for 120-volt system use circuit breaker rated 480 volts).

   b) Branch circuit breaker ratings:

      1) For 120-volt system, use 277-volt rated circuit breakers.

      2) For 240-volt system, use 480-volt rated circuit breakers.

      3) For 480-volt system, use 480-volt rated circuit breakers.

   c) Short circuit interrupt rating: All service equipment and circuit breakers must have equal or greater ratings than available fault currents of the system.

9.) Provide separate circuit(s) for sign illumination, navigation lights and aviation lights.

10.) Permits are required for conduit on railroad right-of-way and such installation should be avoided due to expenses and time involved.

11.) Switching Control.

   a) 1000 watt or less total connected load may be controlled by one photoelectric relay.

   b) Load over 1000 watt should be controlled by lighting contactor(s) and one photo electronic relay. Provide test switch for daytime maintenance.

6.3 Optional

1.) Overhead distribution system.

2.) Design and construction of distribution system by others.

7.0 TEMPORARY LIGHTING

Provide necessary lighting during construction of the project. Designer should consider traffic control plans of the project.

7.1 References

National Electrical Code

Project Special Provisions

ODOT Standard Specifications

National Electrical Safety Code

ODOT Standard Drawings

Manufacturer's Catalog

7.2 Standard

1.) High-pressure sodium lamps.

2.) Average maintained horizontal illumination method utilizing computer analysis for horizontal and vertical alignment of roadway.
    a) Average luminance = 8 lux (0.8 fc) minimum.
    b) Minimum Point = 2.0 lux (0.2 fc).
    c) Uniformity Ratio.
        1) Average to minimum = 4:1 to 6:1.
        2) Maximum to minimum = 15:1 or less.

3.) Critical (decision points) areas of roadway = 13.0 lux (1.2 fc).

4.) Maintenance Factor = (Luminaire dirt depreciation factor) times (Lamp lumen depreciation factor).
    a) Luminaire dirt depreciation factor.
        1) New equipment = 0.95.
        2) Used equipment = 0.8.
    b) Lamp lumen depreciation factor.
        1) Temporary lighting life 1 year and less = 0.95.
        2) Temporary lighting life 1 year to 2 years = 0.90.
        3) Temporary lighting life over 2 years = 0.73.
    c) Use minimum amount of equipment to provide temporary illumination.
    d) Minimize the number of pole placement and pole relocation to cover entire construction stages.
    e) Use aerial distribution system unless the nature of construction requires underground distribution. (Example: bridge work)
    f) Wood poles.
        1) For one year or less of construction period, no treatment on wood poles is required.

2) For over one year of construction period, treatment on wood poles are required.

g) Use 9.2 m (30 foot) setback from edge of travel lane and 1.5 m (5 foot) behind face of barrier with 1.8 m (6 foot) minimum luminaire arm (luminaire should be in front of barrier face). Setback limits may vary for urban area roadway.

7.3 Optional

1.) Other light source may be used when design concept is to match and blend in with existing roadway luminaires.

2.) Project area and scope is described by the state and design is done by the contractor.

8.0 PARTIAL INTERCHANGE LIGHTING

Provide roadway lighting on essential parts only of the interchange. For full interchange or continuous lighting, consult with State Traffic Engineer.

8.1 References

Roadway Lighting Design Guide. American Association of State Highway and Transportation Officials (AASHTO), Washington D.C., 2005.

8.2 Standards

1.) On Ramps - Standard of two poles at merging sections. Ramps in developed urban or suburban areas and ramps with high truck traffic may need more coverage. Ramps with longer acceleration lanes or complex alignment may need more coverage.

2.) Off-Ramps - Standard of three poles to cover gore area. Ramps with complex alignment or roadside features may need additional coverage or pull through light.

3.) Ramp Terminals - Standard of two poles at the intersection. One pole may be sufficient in rural area or T shape intersections. A wide intersection with crosswalk or raised island and a crossroad with physical median controls or channelization may need more coverage.

9.0 UNDERPASS AND TUNNEL LIGHTING

Provide adequate roadway lighting necessary for safe and efficient traffic operation through underpasses and tunnels.

9.1 References

Roadway Lighting Design Guide. American Association of State Highway and Transportation Officials (AASHTO), Washington D.C., 2005.

IESNA – Recommended Practice for Tunnel Lighting (IES-RP-22)

9.2 Standard

1.) Underpass illumination is not part of the standard coverage. Exceptions: pedestrian & bicycle facilities under structure; merge & diverge areas under structure; wide structures (70+ feet) may be considered.

2.) In areas of continuous lighting, the luminaires adjacent to the underpasses should be placed such that the need for supplemental underpass luminaires may be eliminated.

3.) High-pressure sodium lamps.

4.) Designer should conduct a research on tunnel and tunnel lighting and use engineering judgment on selecting luminaire types, sizes, locations, orientation, etc.

5.) Use least amount of equipment to meet lighting requirements.

6.) Existing lighting may be replaced with an upgraded system with light levels below RP-22 design levels if there is engineering and safety justification to do so. Replacement lighting may be designed so that illumination levels are approximately the same if there is a minimal crash history.

7.) The daytime entrance zone light level is dependent upon the brightness features within the motorist's view on the portal approach. Utilize 2-3 light level switching to provide proper amount of lighting according to different ambient lighting conditions.

10.0 SIGN LIGHTING

When signs are constructed with retroreflective sheeting, they are not illuminated. Check with the sign designer of the project on general requirement / special need.

10.1 References

Project Special Provisions

Roadway Lighting Design Guide. American Association of State Highway and Transportation Officials (AASHTO), Washington D.C., 2005.

ODOT Standard Specifications

10.2 Standard

1.) Metal Halide or Induction light type.

2.) Use separate circuit(s) for sign illumination and use common conduit with roadway illumination circuits where possible.

3.) No roadway illumination pole located within 20 m (70 feet) of lighted sign.

4.) Size the conductors to keep the circuits within voltage drop limit that is calculated with at least twice the amount of connected load (Signs are frequently enlarged or added).

5.) In the area prone to vandalism, provide polycarbonate shield for luminaire (example: Around sidewalk on bridge).

6.) Install a cabinet with appropriate circuit breakers on or near sign support for maintenance.

7.) Provide special provisions for sign illumination:
    a) Sign number.
    b) Sign support type.
    c) Sign stationing.
    d) Sign size.

11.0 AVIATION AND NAVIGATION LIGHTING

Ensure longevity and dependability of the system.

11.1 References

FAA's – Obstruction Marking and Lighting

Federal Register – Rules and Regulations

11.2 Standard

1.) Navigation Lighting.
    a) See Coast Guard permit for bridge lighting requirements.
    b) Match existing system, when no permit is obtained.
    c) Provide separate circuit for navigation lights.
    d) Use equipment that is the most simplified type and requires the least amount of maintenance.

2.) Aviation lighting.
    a) Check with FAA for design application and consult with designer in preliminary design unit on the glide path angle.
    b) Pick FAA approved equipment when possible.
        1) Obstruction lights.
        2) Beacon lights.
        3) Photo electronic control.

12.0 ADDITONAL SOURCES

Roadway Lighting Design Guide. American Association of State Highway and Transportation Officials (AASHTO), Washington D.C., 2005.

Oregon Revised Statues, Title 59 810.010 "*Road Authorities (Jurisdiction)*" State of Oregon, 1999 Edition.

Federal Highway Administration Rules and Guidelines

Code of Federal Regulation – Title 23 Sub-Chapter “G”

Federal Aviation Administration’s “Obstruction Marking and Lighting” advisory circular

Proposed Construction or Alteration of Objects that may affect the Navigable Airspace

Local Agency Agreements, League of Oregon Cities and Association of Oregon Counties

“Guidelines and Working Agreements for Local Government Programs” (p.p. 32-33)

Local Officials Advisory Committee (local design standards)

“American National Standard Practice for Roadway Lighting RP-8”

(Illuminating Engineering Society of North America)

AASHTO Roadside Design Book