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Part 11 - HIGHWAY LIGHTING

1100 GENERAL

1100-1 Introduction

This TEM Chapter provides guidelines for use in developing standard, uniform lighting systems. Chapters 1140 and 1141 provide design and plan production information, respectively. Additional highway lighting design information is found in the HL series of traffic control Standard Construction Drawings (SCDs), and as noted in Chapter 1143, the related specifications are addressed in C&MS Item 625 and C&MS 725.

1100-2 Construction Projects

Chapter 140 addresses the general application of ODOT standards, specifications and standard construction drawings to construction projects. Chapter 1150 provides additional construction related information specific to highway lighting.

1100-3 Force Account (ODOT Operations) Work

Districts performing force account lighting work must comply with the requirements in the OMUTCD and this Manual. It is recommended that the Districts follow the provisions in the applicable highway lighting related SCDs and Construction and Materials Specifications (C&MS) sections as well. It should be recognized, however, that the information in the C&MS and SCDs does not necessarily provide the only method to achieve a given objective.

Chapter 1160 addresses ODOT preventive maintenance guidelines and standards for highway lighting.
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1101 DISTRICT SYSTEM LIGHTING PLAN (DSLP)

Each District should develop and maintain a District System Lighting Plan (DSLP). This is typically a GIS thematic map that uses a systematic approach to show both the District’s existing and future highway lighting. The DSLP is intended to provide for a uniform system and to improve maintenance efficiency with regard to factors such as partial, complete, conventional, high-mast and composite/hybrid designs. It allows the District to set priorities for the allocation of available funding for roadway lighting projects, and should be used as a guide in making Light & Don’t Light decisions.

The DSLP is composed of county maps merged into a district-wide map. The twelve DSLPs make up a Statewide System Lighting Plan (SSLP). Through the use of the DSLP and SSLP a consistent systematic treatment can be insured. Each DSLP database should be updated a maximum of every five years.

GIS requires a database made up of the existing physical inventory records. Suggested data and codes that should be used in the DSLP are shown in Tables 1197-1 and 1197-2, respectively.

There are a number of decisions to be made to create the DSLP. These decisions will involve not only the examination of each of the various intersections, interchanges and roadways in the highway system, with regard to the engineering merits of lighting that particular location, but they will also involve insuring equality of treatment of similar locations, prioritizing the planned changes, and forecasting the availability of resources.

1102 JURISDICTIONAL BOUNDARIES

Care should be exercised in defining the limits of highway lighting and individual circuits in regards to jurisdictional boundaries. Existing ownership and maintenance of various roadways and other facilities should be considered. Layout and extent of circuits will determine maintenance and power usage charge responsibilities.

These issues should be addressed through appropriate planning and design of the lighting system, and appropriate prearranged agreements with local jurisdictions.

Where new lighting systems cross existing jurisdictional boundaries to serve a complete area, additional circuits and control centers should be utilized to cleanly separate the units between maintenance areas. This will simplify billing practices. Generally, each jurisdiction should have its own Power Service.

Where new jurisdictional boundaries cross existing lighting systems, consideration should be given to assigning (by written agreements) maintenance responsibilities to one entity.
1103 WARRANTS and GUIDELINES

1103-1 General

Lighting warrants are based on the need for highway lighting and the benefits derived from lighting. In justifying lighting, many factors should be considered, including traffic volume, speed, nighttime road use, night accident rate, road geometrics, general night visibility, economic benefits and future increase in capacity or changes in road use.

1103-2 Warrants for Highway Lighting

Warrants for freeway and interchange lighting are shown in Table 1197-3. These are derived from the AASHTO publication titled An Informational Guide for Roadway Lighting. The ability to satisfy these warranting criteria does not, in itself, necessitate that lighting be installed. Warranting criteria determine location eligibility for lighting; however, there are numerous other factors which must be considered.

For each of the levels of highway lighting shown in Table 1197-3 only one of the Cases need be achieved to meet warrants. However, consideration should be given to whether a location meets only one or all warranting conditions.

1103-3 Accident History

Several factors may contribute to an increase in night accidents, such as:

1. Lack of adequate visual information.
2. Glare from background lighting and headlights.
3. Problems with vehicle lighting.
4. Driver fatigue.
5. Increased use of alcohol and other drugs.
6. Declining visual capability, especially with older drivers.

There is little research on the impact that lighting has on reducing accidents. However, lighting can provide an increase in highway safety by impacting the above mentioned factors.

1103-4 Land Use

The area surrounding a proposed lighting facility must be taken into account when considering the different types and intensities of light needed for a lighting plan. American National Standard Practice for Roadway Lighting (RP-8) sponsored by the Illuminating Engineering Society (IES) defines three general categories for land use: commercial, intermediate and residential:

1. Commercial - Commercial areas tend to create a heavy area of background lighting. High-mast or low-mast towers are well suited to these type of areas. Towers will blend in more with the surrounding area and yet still light the roadway to the needed level.

   In Table 1197-4, “commercial” refers to that portion of a municipality in a business development where ordinarily there are large numbers of pedestrians and a heavy demand for parking space during periods of peak traffic, or a sustained high pedestrian volume and a continuously heavy demand for off-street parking space during business hours. This definition applies to densely developed business areas outside of, as well as those that are within, the central part of a municipality.
2. Intermediate - These areas have a blend of commercial or residential types of land use. Multi-family residential rental property owners are much like industrial and commercial property owners in that lighting, while at lower levels, is still needed for security. Therefore, they are usually not bothered by any light trespass from adjacent highway lighting units.

Low-mast towers or conventional poles tend to work best in these areas. High-mast towers will work, but the designer must consider the impact they will cause to the residential area. Common complaints are heavy light trespass on non-roadway areas and perceived glare from the visible part of the light bulb or fixture (the part not under a metal shroud).

In Table 1197-4, “intermediate” refers to that portion of a municipality which is outside of a downtown area, but generally within the zone of influence of a business or industrial development, often characterized by a moderately heavy nighttime pedestrian traffic and somewhat lower parking turnover than is found in a commercial area. This definition includes densely developed apartment areas, hospitals, public libraries and neighborhood recreational centers.

3. Residential - Owners of single family residential property are more sensitive to light trespass from adjacent highway lighting units, especially if the owner occupies the property. The needs of the traveling public must be balanced with the concerns of the surrounding residents. Low-mast towers and conventional lighting offer the best solution for this type of area. Low-mast towers in conjunction with one or two luminaires will generally light the area within the highway right-of-way and have very little light trespass. They also do not tend to cause the classic light tunnel effect produced when using conventional lighting.

At times, these residents are also concerned with the aesthetics of highway lighting units that stand above the surrounding area or have drop glass refractors. If high-mast lighting is proposed, it is recommended that a public meeting be held to generate local input.

In Table 1197-4, “residential” refers to a residential development, or a mixture of residential and commercial establishments, characterized by few pedestrians and a low parking demand or turnover at night. This definition includes areas with single family homes, townhouses, and/or small apartments. Regional parks, cemeteries and vacant lands are also included.

1103-5 Background Lighting

Background lighting has several effects on a lighting system that should be noted.

When the surrounding light is minimal, the transition from lighted sections to unlighted sections should be gradual. Sudden changes in lighting can cause a visual blind spot. The driver’s eyes must be given sufficient time to adjust to the new lighting level.

In commercial areas where the surrounding light is more prevalent, lighting should be increased to more closely match the existing commercial lighting. This will help overcome the light trespass from the surrounding area.

1103-6 Special Locations

1103-6.1 General

There are a number of locations other than freeways and interchanges for which lighting may be considered. Specific warrants are not available for these other locations. Primary concerns are typically related to safety issues. Quite often illumination levels for these locations will differ from standard freeway and interchange lighting.
1103-6.2 Intersections

Lighting may be provided at intersections to enhance safety and to improve visibility of the intersection and approaches.

Intersections with a high percentage of night accidents or a high volume of pedestrian traffic during the hours of darkness should be considered for lighting.

Intersections with sight distance limitations, unusual or complicated geometrics, channelization, skewed approaches, high volumes, unusual traffic patterns, turning roadways, protected turning lanes or driver recognition problems may benefit from illumination.

Lighting units should be combined with signal and sign supports wherever feasible to minimize clutter and obstacles within the intersection and approaches. When lighting is utilized at channelized intersections and at intersections on turning roadways, units should be placed to illuminate protected turning lanes, at radius points and at approaches to divided areas and traffic islands.

1103-6.3 Pedestrian Walkways

Walkway lighting may be considered for security and aesthetic reasons. Walkway lighting may also include landscape or decorative lighting. Lighting of walkways may significantly increase use during the hours of darkness. Lower voltages (120 volts), vandal-proofing and safety issues should be taken into consideration. For example, control centers should be securely padlocked, wiring and anchor bolts enclosed and sharp edges and corners should be eliminated.

1103-6.4 Weigh Stations

Lighting and levels of lighting provided at weigh stations should take into account the full range of activities and needs of the various agencies utilizing these facilities for enforcement. Besides weighing, various degrees of inspection may be conducted. Temporary storage of detained cargo may also require lighting for security reasons.

Exit and entrance ramps at these facilities should be provided with at least partial interchange lighting (as defined in Section 1105-5). The weigh lane from intersection to intersection over the scale and the inspection and parking area behind the scale house should be lighted with the intensity and uniformity normally provided for continuous freeway lighting, with additional low-mounted floods provided for the reading of vehicle markings, observation of vehicle undercarriages and position on the scales from the operator’s position within the scale house.

1103-6.5 Park and Ride Facilities

Park and ride lots present two lighting requirements. The first is for the mixing of vehicular and pedestrian movements. The other is for security if the lot remains open late (after the evening peak and before the morning peak). Lighting for these facilities should be divided into three areas: drive intersections with adjacent highways, the drives themselves and the parking areas.

1103-6.6 Bicycle Facilities

Bike paths are facilities which are independent of the roadway. They may double as pedestrian or recreational corridors. For these facilities, lighting is more of a security measure and decisions are made based on the amount of night use to be permitted or encouraged.

A bicycle lane is a dedicated lane provided contiguous to the lanes for motor vehicles, as part of a roadway. In this case, the visibility of the bicyclist and lane becomes more important. Lighting should be considered both: 1) to assist the motorist to detect and allow for the bicyclist; and 2) to assist the bicyclist in detecting and avoiding debris in the bike lane, and in compensating for or avoiding pavement irregularities.
School Zone lighting may be considered where a significant pedestrian volume exists. Accident prevention should be considered if a significant volume of turning or stopping vehicles are in potential conflict with pedestrian movements.

Appropriate School Zone signing should be in place before lighting is installed. See Part 7 for further information about School Zones.

1103-6.8 Sign Lighting

It is common practice to power the luminaries for sign lighting from the roadway lighting circuits. See Chapter 212 for further information on sign lighting.

1103-6.9 Underpasses and Tunnels

1103-6.9.1 Underpasses

Underpasses should be evaluated to determine if existing underpass illumination is adequate or needs to be supplemented. Artificial illumination is normally not needed for underpasses that are less than 75 feet in length. However, both skewed underpasses and parallel underpasses less than 40 feet apart may need underpass lighting regardless of their length. Each underpass should be evaluated on its own merits.

The evaluation of lighting intensity and uniformity for the underpass and adjacent highway should be made under both daytime and nighttime conditions. When the length of the structure limits the amount of light from natural daylight or adjacent luminaires located outside the structure, the need for lighting units should be evaluated. Factors to consider include lighting design criteria (see Chapter 1140), the extent, if any, that shadows are produced, and the extent, if any, that lighting intensity and uniformity are compromised. The limited adaptability of older drivers to changes in illumination should also be a factor in determining the need for lighting.

Determination of the need for lighting units for new construction should be made on the basis of design criteria as well as direct comparisons with existing underpasses, to assure consistency of underpass lighting treatment within an area.

Additional guidance is available in the latest version of ANSI/IES Recommended Practice for Tunnel Lighting (RP-22), the AASHTO Roadway Lighting Design Guide (GL-6), and the NFPA Standard for Road Tunnels, Bridges, and Other Limited Access Highways (NFPA 502).

1103.6.9.2 Tunnels

All ODOT design projects should require use of the TEM and RP-22 for tunnel lighting design. This requirement should be in the project Scope of Services. Lighting design assistance for underpasses and tunnels is available from the Office of Roadway Engineering.

The definition of a “tunnel” can vary, depending upon the particular engineering application and standards documents referenced. For highway lighting, ODOT defines a tunnel using definitions very similar to the definition in Chapter 5 of the AASHTO Roadway Lighting Design Guide (GL-6).

Tunnel: A structure of any type that surrounds a vehicular roadway and is longer than an underpass (e.g., greater than 75 feet), and requires supplementary daytime lighting.
Short Tunnel: A tunnel is considered “short” if its length from portal to portal is equal to or less than the wet-pavement minimum stopping sight distance (SSD) as recommended by the AASHTO Policy on Geometric Design of Highways and Streets for the vehicle operating speeds of the tunnel roadway and approaches. A short tunnel has only one lighting zone.

Long Tunnel: ODOT defines a “long” tunnel as one whose length from portal to portal is greater than the wet-pavement minimum stopping sight distance (SSD). A long tunnel has two or more lighting zones.

1103.6.9.3 Warrant for Daytime Tunnel Lighting

Designers should use RP-22 Chapter 6 by default for tunnel lighting design. However, for Short Tunnels only, ODOT allows the following alternative procedure to help determine if the installation of daytime lighting is warranted. This procedure derives from the AASHTO Roadway Lighting Design Guide (GL-6), Chapter 5, and the British Standard Code of Practice for the Design of Road Lighting Part 2 (BS 5489-2:2003), Annex C. This procedure is generally simpler than the RP-22 procedure and suitable for low-speed, low-traffic-volume applications. ODOT accepts this design method only with approval from the Office of Roadway Engineering, and usually only for lower design speeds.

1. Assume the entire tunnel entrance portal is in view from the perspective of an approaching motorist. Place the driver no closer than one Stopping Sight Distance (SSD) from the entrance portal. That gives the driver ample distance to stop if there is a visible obstruction in the tunnel without passing into the entrance portal.

2. Create a perspective drawing from the driver’s point of view that shows both the entrance and exit portals. Calculate the area ratio of the exit portal to the entrance portal from this drawing.
   a. For approach speeds of less than 35mph, if the exit portal area is less than 50% of the entrance portal area, daytime lighting should be installed.
   b. For approach speeds of 35mph or more, if the exit portal area is less than 80% of the entrance portal area, daytime lighting should be installed.
   c. Curvature of the structure must be considered. Some structures, such as curved underpasses, will warrant daytime lighting at shorter lengths than similar straight structures.

1103.6.9.4 Need for Tunnel Fire Protection

All ODOT design projects should require use of the TEM and NFPA 502 for tunnel fire-protection design. This requirement should be in the project Scope of Services. Fire protection can include both alarm and suppression facilities. Contact the Office of Structural Engineering and the Office of Roadway Engineering for assistance. Additional design information on fire protection is located in 1140-4.6.

It is important to note that the Authority Having Jurisdiction (AHJ) determines the applicability of NFPA 502 to a given structure. As defined by NFPA 502, the AHJ is a broad term. The AHJ typically includes a local fire department as well as ODOT, and sometimes includes other agencies.

NFPA 502 Table 7.2, Road Tunnel Fire Protection Reference, is a convenient tabulation of Fire Protection System requirements. Copies of the table are available from the Office of Roadway Engineering. Both planners and designers should consult this Table whenever a tunnel of any length is part of a project. NFPA 502 categorizes tunnels by length. Most tunnels in Ohio will be NFPA Category X (less than 300 feet) or Category A (between 300 feet and 800 feet). Planners and designers should note that a Category A tunnel carries a mandatory requirement for a fire protection standpipe and water supply.
1103.6.9.5 Need for Tunnel Traffic Control and ITS Devices

NFPA 502 has requirements for traffic control devices to stop approaching traffic during certain events (e.g., a fire). This may include traffic control devices on the adjacent roadway network. Contact the Office of Roadway Engineering for assistance.

In addition, there is often a need for CCTV tunnel monitoring cameras and other devices requiring integration with ODOT’s ITS architecture, such as Dynamic Message Signs and Ramp Signals. Contact the Office of Traffic Operations for assistance. Additional design information on traffic control and ITS devices is located in 1140-4.6.

1103-6.10 Long, High Bridges

Bridges have a tendency to freeze before the roadway and typically do not have the clear zone recovery areas of adjacent pavement. Roadways on bridges of such height and length that the normal highway background reference is lost against the sky or water can benefit from highway lighting even though the adjacent roadway is unlit.

1103-6.11 Rest Areas

Rest areas have a considerable mixing of both vehicle-to-vehicle and vehicle-to-pedestrian traffic. Therefore, parking lots and sidewalks between parking areas and service buildings should be lighted for night use. The “green space” surrounding the parking areas and service buildings should have security lighting for the protection of motorists and for deterrence of unauthorized or criminal use.

Rest areas which are characterized by high exit speeds from the roadway, served by long ramps from the exit to the parking areas, and/or with considerable truck parking along the ramps should have fully lighted ramps. These types of conditions are commonly found at rest areas along freeways, but may be found on other highways. Higher exit speeds and the presence of large trucks parking along the ramps, legally or otherwise, create the need for special care in the placement of the poles and luminaries. The poles should have sufficient offset from the ramp pavement to prevent pole knockdowns by tractor-trailers attempting to parallel park. Luminaries should extend over the ramp pavement to eliminate shadows from parked trucks which would obscure ramp pavement and pedestrians walking along the ramp.

Rest areas which are characterized by lower exit speeds, served by driveways or shorter ramps, and without truck parking, should normally not require lighted driveways. These types of conditions are commonly found at rest areas located on highways other than freeways. Lighting should be provided at the intersections of the driveway and the highway. Lighting should be considered when the driveways are of extreme length or large truck parking occurs along the driveway.

1103-6.12 Miscellaneous Lighting

There are other unique applications where lighting may be considered which are not detailed by this Manual, such as for landscaping or for architectural and aesthetic considerations.
1104 CONSISTENCY OF TREATMENT

1104-1 General

Lighting warrants and guidelines are discussed in general in Chapter 1103 and the warrants for freeways and interchanges are specifically addressed in Table 1197-3. The purpose of warrants is to justify lighting at a particular location. The decision to actually install lighting, and to what extent, is dependent on many other factors, such as, District priorities, project cost and participation, available funding, public input, and economic benefits and public safety. It is also desirable to be consistent in treating similar situations in a similar manner. This desire for consistency makes the DSLP approach described in Chapter 1101 particularly helpful.

1104-2 System Consistency

The District System Lighting Plan (DSLP) and Statewide System Lighting Plan (SSLP) described in Chapter 1101 should be used to promote and insure a consistent and systematic treatment. The DSLP graphically displays lighting information, and allows those familiar with the locations in the area covered by the map to easily find the disparities between similar locations and to determine the action required to mitigate any disparities.

1104-3 Fixture Consistency

In all areas where ODOT is responsible for the operation and maintenance costs (whether directly or by reimbursement agreement) of highway lighting, the standard design should be based upon a solid-state (LED) light source employed at the highest practical mounting height consistent with the geometry and land use of the area being lighted.

In other areas, such as along service roads or city streets, where a local jurisdiction will be responsible for operations and maintenance costs, they may request use of other light sources to maintain consistency with existing street lighting systems. However, in view of the emphasis on energy conservation, extensive use of light sources other than solid-state (LED) should be discouraged (see Section 1130-6).

1104-4 Correlated Color Temperature (CCT) Consistency

In all areas where ODOT is responsible for operation and maintenance costs of highway lighting, the District shall coordinate the appearance of adjacent sections of lighting to minimize adjacent areas of significantly different correlated color temperatures (CCT). ODOT specifications for solid-state (LED) luminaires call for CCT = 3000K. Some local jurisdictions use CCTs of 4000K and higher. HPS CCTs are around 2200K. These differences in the apparent color of roadway lighting sources are sometimes noticeable to drivers, and although they represent no driver safety issue, adjacent lighting clusters with different CCTs shall be avoided.

The best way to avoid adjacent clusters of varying CCT is through careful project planning while referencing the DSLP. Projects installing new lighting may need to upgrade adjacent lighting clusters to match. Physical separation between lighting clusters is another treatment, and a separation of at least 30 seconds of travel time is suggested.
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1105 LEVELS OF LIGHTING

1105-1 General

For purposes of discussion, various levels of lighting service have been identified and are described in the following sections. General warrants and guidelines for highway lighting are discussed in Chapter 1103. The warrants for freeway and interchange lighting are shown in Table 1197-3.

1105-2 Continuous Freeway Lighting (CFL)

This type of lighting is the installation of fixed light sources along a section of freeway to provide uniform illumination along its length. This type of lighting is more desirable in urban areas where development exists and traffic speed changes occur due to diverging and merging lanes. Continuous freeway lighting should be designed to provide initial horizontal illumination levels as prescribed in Chapter 1106.

1105-3 Complete Interchange Lighting (CIL)

This type of lighting is used to provide uniform lighting throughout an interchange, including all points of the diverging and merging traffic lanes, turn lanes and mainlines within the interchange. Interchange lighting should be designed to provide initial horizontal illumination levels as prescribed in Chapter 1106.

1105-4 Intermediate Interchange Lighting (IIL)

Intermediate interchange lighting is a design in which the initial lighting units to be installed are considered to be the preliminary stage of a complete lighting system. Intermediate interchange lighting should be considered in urban, and occasionally rural, areas where complete interchange lighting is not yet warranted under Table 1197-3. This type of lighting should be utilized if there is reasonable probability that complete interchange lighting (CIL) will eventually be warranted based on the land use guidelines in Table 1197-3. Consequently, lighting designed under this procedure should complement eventual complete interchange lighting. Thus, the lighting layout for each interchange under this scenario should include the future proposed light locations.

1105-5 Partial Interchange Lighting (PIL)

Partial interchange lighting differs from complete and intermediate interchange lighting in that later stages of more fully developed lighting are not anticipated during the expected life of the initial system. Partial lighting will generally occur in rural areas, and occasionally urban areas. Lighting provided under this concept will generally be limited to diverging lanes, merging lanes and ramp intersections. Lighting intensity and uniformity under Section 1106-2 will not be satisfied.
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1106 LIGHTING CRITERIA

1106-1 General

The following sections reflect design values for illuminance levels. There may be conditions under which somewhat different levels are desired or necessary. The lighting designer should use all available pertinent information in reaching a decision regarding the level to be used for any specific street or highway.

There are many locations where very high levels of illuminance are provided for streets in the central business district. The reason is usually a commercial consideration directed towards making the downtown business area more appealing to shoppers. Generally, levels considerably higher than those shown in Table 1197-4 (which is based on AASHTO criteria) must be justified on some basis other than solely for the safe and efficient flow of traffic.

1106-2 ODOT Lighting Criteria

1106-2.1 General

The following criteria should be used for ODOT highway lighting projects. However, since projects may be developed for special purposes, and since FHWA reserves the right of approval on an individual project basis, the designer should coordinate proposed criteria with the Office of Roadway Engineering early in the development of planning for highway lighting.

1106-2.2 Intensity

The initial average intensity for lighting ODOT-maintained freeways shall be 1.0 to 1.2 footcandles, and all lighting design should attempt to approximate the 1.2 value without exceeding it, except where this limitation results in an unacceptable uniformity ratio as specified in Section 1106-2.3. For non-freeway lighting, reference should be made to Table 1197-4 for recommended average maintained horizontal illumination levels.

1106-2.3 Uniformity

The design uniformity ratio for interchange lighting or for continuous freeway lighting shall be between 3:1 and 4:1. However, where partial or intermediate interchange lighting is being designed, it is obvious that the desired uniformity cannot be obtained until all initially-omitted lighting units are installed in accordance with a complete interchange lighting plan based upon the stated design ratios.

The 3:1 ratio of uniformity is acceptable in all cases, and the 4:1 ratio should not be exceeded. Tower lighting is typically in the range of 2:1 to 3:1.

1106-3 Local Criteria

Various jurisdictions may have different criteria from what is listed in this Manual. The local jurisdiction must provide ODOT with the approved policy, ordinance or established standard and obtain approvals prior to the beginning of the design of the project.
1107 GUIDELINES FOR REDUCTION/REMOVAL OF EXISTING LIGHTING

1107-1 General

Where an existing highway lighting system is no longer warranted or cost effective, it should be considered for either a reduction in the lighting level or removal of the lighting. Where light levels are reduced, they should not be reduced below the criteria for partial interchange lighting.

After the decision has been made to remove or reduce the lighting system, the appropriate lights should be turned off but left in place for a period of one to four years. For all highway lighting systems, an accident analysis study will be required during this time period to determine the effects of the reduced lighting.

1107-2 DSLP Evaluation

If an existing lighting system is not cited in the DSLP as a location that should be lit, or is lit to a greater extent than what the DSLP recommends, the location should be studied. If the guidelines recommend partial or no lighting, the lighting should be reduced to the level specified in the DSLP.

1107-3 Change in Land Use

At an interchange, where a major traffic generator has permanently closed or other significant highway or land use changes have occurred, the existing interchange lighting should be studied for meeting the lighting guidelines. If the guidelines are not met, the lighting system should be reduced or removed as specified in the DSLP.

1107-4 User Objections

1107-4.1 General

If a substantial percentage of residents and local business owners are objecting to the lighting, verification shall be made that the lighting guidelines are still met and that the lighting coincides with the DSLP.

1107-4.2 Existing Complete Interchange Lighting

If the warrants for complete interchange lighting (Table 1197-3) are met and the DSLP recommends complete interchange lighting in this area, other methods should be investigated for reducing the lighting impact outside of the right-of-way (i.e., glare shields). If the guidelines for partial interchange lighting are met or the DSLP recommends it, the location should be reduced to partial interchange lighting.

1107-4.3 Existing Partial Interchange Lighting

If the warrants for partial interchange lighting (Table 1197-3) are met and the DSLP recommends lighting, other methods should be investigated for reducing the lighting impact outside of the right-of-way (i.e., glare shields). If the warrants are not met, or the DSLP does not recommend lighting in this area, the lighting should be removed.

1107-4.4 Agricultural Areas

Some crops (notably soybeans) can be affected by light trespass. The physiological phenomenon, known as photoperiodism, is limited to small portions of agricultural fields near lighting installations. Typically, only high mast lighting installations create enough light trespass to affect agricultural crops. In Ohio, the only commodity agricultural crops affected by light trespass are soybeans (Glycine Max). This effect does not change the overall yield of the soybean field, but it does delay flowering, which subsequently delays maturity. The resulting
non-uniform bean maturation within the field can result in difficult harvesting operations (combine clogging, delays in harvesting portions of the same field), higher average crop moisture readings (grain elevator moisture penalties), or drop losses in the unaffected beans if the producer waits for the affected beans to fully mature before harvesting the entire field. Producers can often modify their harvesting operations slightly to allow complete harvest of the affected field with no net loss: occasional partial or full-width combine swaths are made through the less mature areas of the field, thus mixing the higher-moisture grain with drier grain from combine swaths taken in more mature areas of the field.

The photoperiodic effect for soybeans is typically limited to within a few hundred feet of the base of a high mast light tower, so the total area affected within a typical agricultural field is quite small. The observed effect in Ohio is limited to areas of the field experiencing more than 0.1fc illumination. Therefore, ODOT recommends that lighting designers allow no more than 0.1fc of light trespass into adjacent agricultural fields. Asymmetric luminaires, shields, tilting of luminaires, use of low-mast or conventional supports, and careful placement of high mast supports can all be used by designers to meet this trespass criterion.
1120 MATERIALS AND HARDWARE

1120-1 General

There are several different types of hardware available for highway lighting. All new ODOT owned and maintained lighting power service should be three-wire (single-phase) or four-wire (three-phase) grounded neutral design. Also, highway facilities that are ODOT-maintained should utilize the standard lighting hardware of high-mast, low-mast or conventional poles.

1120-2 Patented or Proprietary Materials, Specifications or Processes

The use of patented or proprietary materials, specifications or processes is discussed in Section 120-4.

1120-3 Purchasing Materials for Installation and Use by Local Agencies

To help encourage uniformity and provide a method whereby local agencies can buy traffic control materials and equipment using Federal funds, Sections 120-4 and 120-5 describe processes that have been established whereby local agencies can purchase such items through ODOT.

1120-4 Existing Aesthetic Lighting Systems

The area that is to be lighted should be considered when a lighting project is initiated. If a project will only affect a small portion of an existing lighting system, (i.e., one or two poles) the same brand of hardware and luminaire should be specified in the plan. If a project will effect a larger portion of an existing lighting circuit (i.e., one or more circuits), the designer should evaluate the situation, and with the agreement of the maintaining agency, require either that:

1. Use the same brand of hardware and luminaire as the existing lighting system; or
2. Replace the entire existing system with a different brand of hardware and/or luminaire.

This will prevent a lighted area from having different lighting patterns resulting from the use of different brands of luminaires and also prevent a lighted area from having different styles of poles.

1120-5 Local Preferences

See Section 120-4 for more information about local preferences and proprietary bids.

In order to be in compliance with C&MS 106.09 (domestic steel), the Office of Materials Management has created an Approved List for decorative steel light poles. Only poles listed may be specified for decorative lighting. There are no exceptions for projects that use Federal and/or State monies. The use of alternate or proprietary bids does not provide an exception to the domestic steel requirement. Foundations and conduits for non-approved poles that would be provided by the locals at their own cost are not eligible for participation.

1120-6 Operating Voltage

In 600 volt class circuits the voltage between any two conductors may not exceed 600 volts. Industry standard voltages are 120, 208 and 277 volts line to ground and 240 and 480 volts line to line. Highway lighting power service from the utility company is generally single phase, 3 wire or 3-phase. Thus the practical luminaire operating voltages are limited to 120 or 240 volts line to ground and 240 or 480 volts line to line for single-phase service and 208 or 277 line to ground for three-phase service.

When a three-phase service from the power company feeds the lighting control center, designers shall limit load imbalance to 15 percent or less of the total connected load kVA.

To help reduce shock hazards, all new ODOT lighting installations should be limited to maximum

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240VAC-to-ground for single-phase service and 277VAC-to-ground for 3-phase service.

1120-7 **Ballasts**

Where ballasts are to be wired line to line (three-wire system), ballasts having an isolated primary winding must be used. Where ballasts are to be wired line to ground (two-wire system), auto-transformer ballasts may be used. When the use of other than conventional (i.e., ovate or cobra head) or high-mast or low-mast luminaires is contemplated, and the luminaire is to be wired line to line, the vendors should be contacted and ask to confirm in writing that the luminaires under consideration are available with a ballast having an isolated primary winding.

1120-8 **Solid-State (LED) Luminaires**

Designers should use Solid-State (LED) luminaires for all new lighting installations.

Older plans originally produced using HPS luminaires should be revised before sale to use Solid-State (LED) luminaires, if possible. After sale, the District shall consider whether a change order is justified to change from HPS to LED. From an engineering standpoint, such a change is almost always worthwhile.

**ODOT** has specifications and an Approved List for Solid-State (LED) Luminaires for highway lighting. These specifications are given primarily by **Supplemental Specifications 813 and 913**. Procedures for manufacturers and vendors to get Solid-State (LED) Luminaires onto the Approved List are documented in **Supplement 1114**. The Approved List is published by the **ODOT Office of Materials Management** on their website.
1130 PLANNING / PROGRAMMING

1130-1 General

The following sections are provided to assist planners and designers in developing standard uniform lighting systems. These sections discuss various aspects of lighting that should be taken into account when planning new, or rehabilitating existing, lighting systems. The following are guidelines and are not meant to override a planner’s engineering judgment.

1130-2 Programming of Projects

Before a lighting project is programmed, whether alone or in conjunction with a roadway project, a preliminary study should be completed. A preliminary study should include the following: Verifying that the project meets lighting warrants where available and is in conformance with the DSLP (Chapters 1101 and 1103); verifying what types of funding will be used (Section 1130-3); deciding what type of lighting is to be used (Chapter 1120); verifying who will maintain the system (Chapter 1102); and deciding what type of power supply is to be used (Section 1120-6). For temporary lighting see Part 6.

1130-3 Funding Considerations

1130-3.1 General

The programming should specify all funding types used on the project. Federal funding for highway lighting is governed by FHWA policy. In general, highway lighting is eligible for Federal participation when warrants and criteria satisfy AASHTO and ANSI requirements (see Chapter 1106) and the project is on a Federal-aid highway system. There may also be occasional special programs involving Federal aid which require approval from offices other than the Ohio Division Office of FHWA. Under such circumstances, it is essential that requests for participation be initiated at the programming stage. State participation in lighting projects shall be as specified in Section 1130-4.

1130-3.2 New Installation

If the proposed lighting system is in more than one funding jurisdiction, all agencies must agree in writing on their portion to be paid. For example, if an interchange that is to be lighted is within the boundaries of two incorporated areas, the funding would typically follow the corporation boundaries. If only a small portion of an interchange is in an incorporated area, an attempt should be made in the design of the lighting to avoid placing any material or equipment within this area.

1130-3.3 Upgrade/Retro-fit

If the existing lighting system is in more than one maintenance jurisdiction, all agencies must agree in writing on their portion to be paid. Any changes in corporation limits from the original installation should be reflected in the funding split of the project and in the new maintenance agreement. It should also be remembered that lighting circuits do not necessarily stop at the project limits and therefore the project’s lighting needs may be greater than expected if only the area inside the project limits is considered.

1130-3.4 Maintenance

If the existing lighting system is in more than one maintenance jurisdiction, each jurisdiction should have independent circuits that do not trespass into other jurisdictions. Each jurisdiction should have a separate control center. The maintenance agreements should be initiated in the planning stages.
1130-4 State Participation

**ODOT** participation in highway lighting projects shall be as follows:

1. On limited-access highways and freeways, **ODOT** will participate in the cost of all lighting system items that are necessary to complete the lighting system. **ODOT** participation will be limited to the cost of a system to provide an average initial intensity in the range of 1.0 to 1.2 foot candles. If a system to provide higher intensities is provided at the insistence of any political subdivision, the added cost of construction and maintenance resulting therefrom shall be borne by that political subdivision.

2. Existing lighting systems on crossroads and streets which cross limited-access highways and freeways without interchange facilities will be rearranged and/or replaced with similar styles and types of systems and equipment to provide a light intensity equal to that provided by the existing system. However, if the rearrangement of the existing road or street creates a need for a greater intensity for the safety of the traveling public, or requires changes in types and styles of system and equipment, modifications to the extent necessary to meet such need and requirements may be included subject to approval by the Assistant Deputy Director of the Development Design Administration.

3. On major improvements of existing highways within municipal corporations, existing lighting systems will be rearranged or replaced, if necessary, to restore light intensities to those previously existing, and in any event, to provide not less than the minimum average maintained intensity as recommended by AASHTO for expressways and highways, and as established by ANSI for urban streets.

4. **ODOT** participation in the eligible costs of such construction, rearrangement, and replacement will be the same as **ODOT** participation in the other construction costs of the project.

5. **ODOT** will not participate in the cost of extensions and betterments to existing publicly-owned lighting systems included in the **ODOT** construction contract at the request of a municipality or other political subdivision.

1130-5 FAA Requirements

The programmer shall verify the location of the project in relation to all airports or heliports. If the project is within a 20,000 feet radius of a public-use or military airport or heliport, the programmer shall perform an Airway/Highway Clearance Analysis to determine if **FAA** notification is required (see L&D Manual Volume 3, Section 1404.1).

1130-6 Light Fixtures

As noted in Section 1104-3, the standard design for highway lighting on **ODOT**-maintained facilities should be based on High Pressure Sodium (HPS) fixtures.

Where a municipality desires to maintain aesthetic consistency for existing street lighting systems by using distinctive unit designs or by painting light poles, specific justification for such designs shall be submitted for **ODOT** approval before Federal funds are authorized. In general, such justification must demonstrate that the municipality is not requesting Federal funding for designs which exceed the **City** standard, and that the distinctive design is used consistently through a reasonably large or historical area within the **City**.

1130-7 Maintenance Concerns

Prior to the programming of the lighting project, the programmer should verify that the **City** or **Village** will be able to maintain the lighting. Typically small **Cities** and **Villages** have lighting provided for and maintained by the local power company. Prior to the programming of a project to replace the existing utility-maintained lighting with **City** or **Village**-maintained lighting, **ODOT** should verify that the **City** or **Village** is capable of maintaining the proposed lighting or that they are willing to contract out the
maintenance of the proposed lighting.

1130-8 **Scope Preparation for Specific Projects**

For each intersection, interchange and roadway affected by the project, the highway lighting should be described as it is to be upon the completion of the project. It should be stated whether the new lighting is to be part of the project or provided by others in conjunction with the project, including a statement that there is to no lighting at the particular intersection or interchange, or on the roadway section if that is the case.
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1140 DESIGN INFORMATION

1140-1 General

Chapter 140 provides general background regarding design information for ODOT projects, including the three-stage review process typically used for traffic control plans. Additional information about lighting design has been provided in this Part.

This Chapter provides the designer with information to satisfy the requirements of ODOT relative to highway lighting construction plans. It is not intended to substitute for nationally-accepted criteria and standards nor to relieve the designer of the responsibility for using personal skills and ingenuity in developing the best possible plan for a specific project. Rather, it is intended to supplement more formal design references and knowledge by explaining policies, criteria, design considerations and plan procedures which experience has indicated are pertinent to the state highway system.

The Lighting Design Reference Packet is available to assist designers with lighting design and plan preparation.

1140-2 General Theory

To properly understand the effects of roadway lighting, one must have a basic understanding of the theory of lighting and the design of roadway lighting. The following sections will outline some basic theory and design principles followed by plan preparation elements. Those wishing to gain a fuller understanding of lighting theory should consult the Illuminating Engineering Society (IES) of North America’s American National Standard Practice for Roadway Lighting ANSI/IES RP-8.

1140-3 Lighting Theory

1140-3.1 General

The act of seeing involves three separate elements: the eye, the visual task and light. Light emitted by a source strikes an object, the object reflects some of the light toward the eye, and the object is seen. Except when light sources themselves are being observed, seeing is by reflected light. Light which enters the eye directly from the source is of no value in the effort to see an object; in fact, it will actually impair vision.

At the low levels of illumination involved in highway lighting, objects are often seen by silhouette rather than by light reflected from the object itself. In this case, the primary concern is surrounding or background brightness, rather than illumination or brightness of the object. For maximum effectiveness, discernment by silhouette depends upon the degree of brightness difference, or contrast between the object and its background.

In highway lighting, as contrasted with interior lighting, the objects to be perceived are relatively large, and visual acuity, or the ability to distinguish fine detail is not involved as a general rule. The most important objective is to create or enhance the brightness contrast between an object and its background, or the roadway surface itself. In all highway lighting, objects are made visible by a combination of two or more methods of discernment. For example, on a well-lighted highway:

1. Distance objects are seen by direct silhouette.
2. Projections above the pavement (the upper portions of pedestrians and vehicles) usually are seen by reverse silhouette.
3. Traffic signs and very close objects are seen by surface detail.
4. Many objects produce glint or highlights on irregular or specular surfaces.
The same light that produces visibility on the highway also produces a negative result known as glare. Glare is any brightness in the field of view that causes discomfort, annoyance, eye fatigue or interference with vision. It may best be described as negative light or light out of place. Glare is a function of intrinsic brilliancy, candlepower toward the eye, distance, contrast, and angular displacement with the line of sight.

Roadway luminaires are classified by the way they transmit and distribute light. The use of various types of reflectors and refractors permits the lighting designer to produce an efficient and aesthetic design. Luminaire classifications are defined in terms of vertical light distribution, lateral light distribution, and the control of distribution above maximum candlepower, known as cutoff. Vertical and lateral light distributions apply primarily to the shape of the roadway area to be illuminated. Both of these distributions can be important when determining the amount of light trespass from a source. Figure 1198-1 illustrates five basic lateral distributions of highway lighting fixtures.

The control of the distribution above the maximum candlepower, known as the cutoff, is important for determining the amount of glare emitted by a fixture. A non-cutoff roadway fixture typically has a dropped lens (a refractor). This allows the light to be more easily distributed from the fixture and permits the illumination design to be less precise; however, it produces more undesirable glare. A full cut-off fixture typically has the dropped refractor replaced with a flat glass, while the reflecting elements inside the fixture have been redesigned to provide control of the light output. This provides much better glare control; however, the illumination design must be much more precise to maintain lighting uniformity. Figure 1198-2 illustrates the effect of non-cutoff and full cut-off luminaires.

The Illuminating Engineering Society (IES) is the recognized authority for the setting of various illumination recommendations, including those for roadway lighting. These standards, as listed in ANSI/IES, RP-8, have been well researched and established as the minimum requirements for the safety of roadways. Several studies have been undertaken in recent years involving test targets placed on roadways. The IES standards have been confirmed during these studies as the minimum requirements for proper illumination with respect to stopping sight distances. To give some idea of the scale of illuminance required for various roadways refer to Table 1197-4.

1140-3.2 Illuminance

1140-3.2.1 General

Illuminance (or illumination level) is defined as the amount of light being transmitted upon a certain area. The English unit for illuminance is the footcandle, which is equal to one lumen per square foot. Illuminance is governed by the inverse square law. The illuminance of an area or object diminishes as the square of the distance.

Highway lighting is generally designed as the illuminance of the area in question. It is based on the premise that, by providing a given level of illumination and a uniformity of distribution, satisfactory visibility can be achieved. The basic calculation for roadway illuminance is as follows:

\[ E_{ave} = \frac{(L \times CU \times LLF)}{S \times W} \]

Where:

- \( E_{ave} \) = average illuminance of the area in horizontal footcandles
- \( L \) = luminous flux of the source in lumens
- \( CU \) = coefficient of utilization of the luminaire (obtained from a photometric data chart supplied by the manufacturer and dependent on the width of the road and the mounting height)
- \( LLF \) = light loss factor (the amount of light that will be lost over time due to dirt accumulation on the luminaire and lamp depreciation - typically 0.7 to 0.8)
- \( S \) = spacing of the streetlight poles
W = width of the pavement to be illuminated

For example, a roadway with a pavement width of 33 feet and a light pole spacing of 164 feet utilizing a luminaire which has an output of 25,000 lumens, a coefficient of utilization of 45 percent, and a light loss factor of 70 percent will have an average illuminance of:

\[ I = \frac{(25000 \times 0.45 \times 0.7)}{164 \times 33} = 1.46 \text{ footcandles} \]

1140-3.2.2 Point-by-Point Analysis

Point-by-point calculations are used to determine the illuminance at a specific location from a “point” source of light. This assumes the source behaves as a point source; consequently, this method cannot be used for linear and area sources. This computational process utilizes a candlepower distribution curve. The inverse square law is used to determine from the values on the distribution curve the levels of illumination at various points on the interchange or area to be lighted.

The illumination in horizontal footcandles at a grid point resulting from one high-mast assembly can be computed by using the formula:

\[ E_h = \frac{cp \cos \theta}{d^2} \]

Where:

- \( E_h \) = illumination at the point in horizontal footcandles
- \( cp \) = candlepower at angle \( \theta \)
- \( \theta \) = the angle from the vertical axis through the system to the point in question
- \( d \) = the distance from the light source to the point in questions in feet

The total illumination at each of the grid points is the sum of the contributions of illumination from the high-mast assemblies within an effective range of the point in question.

Because of the time involved with hand calculations in the point-by-point method, and due to the number of trials which may be required, the point-by-point method is usually accomplished by computer. Generally, computer programs are built around the point-by-point method. Manufacturers have these type programs available and will normally provide design layouts.

1140-3.3 Luminance

1140-3.3.1 General

Luminance is the brightness of an object that has been illuminated by a source. The luminance of an object depends on its material characteristics and reflectance. For example, under the same illuminance conditions a dark object will look less bright than a light object. Since luminance refers to the amount of light reflected back by an object, this object in effect acts as a new source. There is a direct relationship between the luminance of a viewed object and the resulting illuminance of the image on the retina of the eye. The unit of luminance is the footcandle.

Highway lighting may also be designed by calculating the luminance of the roadway surface. This involves determining the reflective properties of the pavement, which can vary dramatically depending if the surface is concrete or asphalt. Although considered superior to the illuminance method, the luminance method is complex and because it involves reflective properties of the pavement, is subject to change over time due to aging of the pavement as well as change associated with weather.
1140-3.3.2 Small Target Visibility (STV)

The visibility of an object is that property which makes it discernable from its surroundings and depends on a combination of the following factors: (1) the difference in luminance between the object and its immediate background (contrast); (2) the angular size of the object at the eye of the observer; (3) the luminance adaptation level to which the eye is exposed; and (4) the duration of the observation. The object that is used for STV is a 7 x 7 inch target. The observer is located on a line parallel to the centerline of the roadway at a distance of 273 feet. Using the four measurements stated above and a series of equations, the visibility level (VL) of the target can be calculated. Visibility models must also incorporate age-related changes in visual processing efficiency that have notable effects on target visibility.

STV is included in the IES Recommended Practice (RP) 8, as one of three methods for demonstrating compliance. Until further study and development of computer programs to more definitively analyze the various factors affecting the visibility level (VL) of the target, ODOT continues support of the illuminance method.

1140-3.4 Headlamps

If we drive in an “empty” road situation (i.e., just one car on the roadway), a proper level of STV is all that is required. High beam headlights produce a very low level of pavement luminance at 200 to 300 feet ahead, yet we can drive quite safely with them as long as we are the only car on the road. The same light that produces visibility on the highway, also produces a negative result known as glare.

In the driving task the most commonly experienced glare is probably that from approaching headlamps on an unlighted highway. The effect is one of shock; the eye has been adapted to relatively low brightness and suddenly is confronted with an extremely bright source, often close to the normal line of sight. The effect may be sufficiently severe to contract the iris, which further reduces the ability to see. The same headlamp fails to glare when encountered in the daytime, although its candlepower is the same day and night. The glare effect is due to excessive brightness contrast, because of the dark surroundings at night.

When the roadway is not “empty,” a reasonably high level of pavement luminance is essential to reduce the adverse effect of glare from the headlights of oncoming vehicles. An adequate level of STV can be achieved with fixed lighting, which also provides much higher level of pavement luminance than do headlights alone.

1140-3.5 Middle Third

The preferred location for overhead sign supports is in the middle third of the design spacing for the lighting units. When the desired location criteria for a sign support does not result in its falling within the preferred area, the following minimum separation between overhead sign installations and lighting units should be maintained:

<table>
<thead>
<tr>
<th>Mounting Height for Lighting Unit Feet</th>
<th>Minimum Separation Feet</th>
</tr>
</thead>
<tbody>
<tr>
<td>32.5</td>
<td>40</td>
</tr>
<tr>
<td>40</td>
<td>60</td>
</tr>
<tr>
<td>50</td>
<td>90</td>
</tr>
</tbody>
</table>

If the lighting unit or the sign support locations cannot be adjusted to maintain the above minimum separation, the lighting unit may be placed immediately in advance of the sign support when a 40 or 50-foot mounting height is used for lighting. However, such a position cannot be used effectively for a 32.5-foot mounting height, and consideration should be given to raising such mounting heights for several units in the general vicinity of the sign support.
1140-3.6 Illumination Criteria

1140-3.6.1 General

In designing a new highway lighting system, the quantity and quality of illumination must first be established.

1140-3.6.2 Average Illumination

The quantity of illumination is that average illumination level which has been established through experience in the lighting profession that represent economic and practical restraints. The quantity of light is referred to as the “average maintained horizontal illumination” and is a function of the classification of the roadway and the area which is served by the lighting system. Breaking this term into its parts, the first term, “average,” refers to the method of measuring the illumination level, and means that this is a mean value of all points within the area being lighted. The second term, “maintained,” refers to the illumination value at some point in time after the system is installed. Maintained illumination takes into account reductions in luminous output due to factors such as lamp lumen depreciation (LLD factor) and luminaire dirt depreciation (LDD factor). Thus, a lighting system begins within an initial illumination level and depreciates to some level less than this. For this reason, the initial design level of illumination is higher than the maintained value. The final term, “horizontal,” refers to the surface on which the illumination is measured, in this case, a horizontal plane, such as the roadway surface.

Average maintained illumination levels currently recommended by the IES for various areas and facilities are shown in Table 1197-4.

1140-3.6.3 Uniformity

The illumination concept of lighting design defines an average quantity of illumination over the pavement surface. This average quantity of illumination can, however, be accomplished by either producing a generally uniform level of illumination over the area or by producing relatively high and low areas of illumination. The latter is not desirable. As a driver passes through areas of relatively high and low illumination levels, his eyes must adapt.

The uniformity of illumination is considered a qualitative means of defining highway lighting. The term used to quantitatively describe uniformity is the uniformity ratio. As the name implies, it is a ratio of various illumination values. Current practice makes use of the Average Level-to-Minimum Point method (average-to-minimum ratio) of calculating uniformity, in which the average illumination is divided by the lowest illumination point encountered within the traveled portion of the roadway. For example, a street with an average illumination level of 2.0 footcandles and a minimum point of 0.5 footcandle would have an average/minimum uniformity ratio of 4:1. Current ODOT criteria requires 3:1 or better for high speeds and high conflict areas, and 4:1 for low speeds and low conflict.

The Maximum-to-Minimum Point method uses the maximum and minimum values within the traveled portion of the roadway. It is felt that the use of a maximum/minimum uniformity ratio more accurately portrays the degree of uniformity, because it takes into account the full effects of the differences of illumination on the lighted roadway. Current ODOT criteria requires a 10:1 or better max/min uniformity ratio.

1140-3.7 Critical Location

Roadways have many areas where the problems of vision and maneuvering of vehicles are complex and require lighting units at critical locations. These locations are in addition to what are commonly called key unit locations at intersections, acceleration and deceleration lanes, underpasses, overpasses, pedestrian bridges and on structures. Key and critical unit locations must be identified for each project prior to developing a traditional (non-high mast) layout where...
light poles are relatively close to the traveled way. These locations are the basis for the ultimate design with additional units filling in the gaps. See Sections 1140-4.4 and 1140-4.6 for specific information.

1140-4 Luminaires and Sources

1140-4.1 General

The design of a highway lighting system involves consideration of visibility, economics, aesthetics, safety and environmental conditions, as well as appropriate material and equipment. The first major step in the design process involves the selection of tentative luminaires and light sources and the selection of one or more tentative lighting system geometric arrangements (conventional or high mast), including mounting heights and lateral luminaire positions, that may provide an acceptable design based on the required uniformity criteria (i.e., average maintained footcandles, ave/min uniformity ratio and max/min uniformity ratio).

As noted in Section 1120-8, ODOT has specifications and Approved Lists related to various types of luminaires.

1140-4.2 Luminaire Placement

1140-4.2.1 General

On freeways or expressways, through lanes normally should be lighted with luminaires having IES Type III medium semi-cutoff distribution as discussed in the American National Standard Practice for Roadway Lighting (RP-8), published by ANSI. Ramps or directional roadways having two lanes or less should have IES Type II medium semi-cutoff distribution luminaires. The Type II distribution should generally be used where the pavement width is less than 1.25 times the mounting height. For wider pavements, the Type III distribution should be used.

ODOT-maintained lighting systems should use high pressure sodium or solid-state (LED) luminaires.

1140-4.2.2 High-Mast Lighting

High-mast lighting, or light towers, have frequent applications, especially in interchange areas and along major freeways. In Ohio, lighting units are considered to be high masted, or towers, when the height of the luminaires is 70 feet or more above the supporting foundation. The more obvious advantages of towers over conventional lighting units are as follows:

1. Because of their increased height and number of luminaires (up to six luminaires per tower), illumination distribution is improved to the extent that a single tower will usually replace from four to eight conventional lighting units. While the increased height of luminaires in itself does not necessarily guarantee lower disability glare, careful system design with towers can result in reducing glare and increasing comfort as the installation is approached and driven through. In general, greater uniformity of illumination can be achieved by a well-designed tower system.

2. Towers are significantly safer than conventional lighting units from the viewpoints of the road user and the maintenance forces. Since towers are located as far as practicable from traveled pavement, the opportunities for impact by errant vehicles are greatly reduced. Maintenance vehicles, equipment and personnel are remote from traffic lanes during servicing operations, which may eliminate the need for temporary traffic control devices and allow for complete concentration on maintenance activities, without fear of interference or distraction from moving vehicles. Since ODOT specifications require that towers be equipped with luminaire lowering devices, the most common maintenance operations are performed at ground level.
3. Daytime aesthetics are improved because of the fewer numbers of poles and their greater distance from the roadway.

*C&MS Item 725.21* discusses detailed requirements for light towers, and the designer should be familiar with that specification when evaluating proposals relative to tower lighting.

### 1140-4.2.3 Solid-State (LED) Luminaires

For an LED lighting system, the designer shall strive to find three interchangeable solid-state (LED) luminaires. If this is not possible, it may be necessary to request a proprietary bid. *Section 120-4* describes the for approval of patented or proprietary materials. A Proprietary Bid Request for Solid-State (LED) Luminaires shall be made in writing to the Office of Roadway Engineering’s Traffic Control Engineer, with a copy to the District. If the proprietary bid is not granted, and three interchangeable solid-state (LED) luminaires cannot be found, then three separate lighting designs (one for each luminaire) shall be submitted by the designer, each constituting an Alternate Bid. These shall be called Roadway Lighting Design A, B, and C, and shall apply project-wide. In addition to the three Alternate Bids, the designer shall specify one of the three designs as the generic bid. The generic bid design will generally be the design among A, B and C that has the highest luminaire count; this helps assure that the Alternate Bid designs can compete on their own merits, often on the basis of having a lower overall luminaire count or power consumption.

### 1140-4.3 Conventional

#### 1140-4.3.1 General

*ODOT* projects scoped for lighting will generally specify whether conventional or high-mast units are to be used in the design. Currently, conventional units refer to a “cobra head” roadway fixture mounted on round tapered poles at a mounting height of nominally 30 to 50 feet. The units are widely used, readily available and economically attractive.

#### 1140-4.3.2 Mounting Height and Wattage

The standard mounting height and luminaire rating combinations used by *ODOT* can be found in *Table 1197-5*.

The designer should always check with the maintaining agency for mounting height and luminaire rating preferences due to replacement stock standardization.

The designer should also note that the mounting height and the support height (as defined in the HL Series of the *Traffic Standard Construction Drawings (SCDs)*) may differ, depending on the pole base type required, and affects the Item Description/Light Pole Design Number, used in the construction plan Lighting General Summary.

#### 1140-4.3.3 Spacing

In designing a lighting system, maximizing spacing of luminaires consistent with good illumination design should be emphasized. From the standpoint of economy and safety, the minimum number of luminaires and supports should be used while satisfying the illumination quantity and quality criteria. Spacing of lighting units will be influenced by mounting heights, lamp sizes, luminaire arrangements, uniformity ratios, illumination levels (footcandles), and special roadway features such as variable pavement widths, sign supports, bridges and other structures, intersection, ramps and utility locations.

Luminaire spacing is calculated using the following equation:
**Luminaire Spacing** = \( \frac{LL \times CU \times LLD \times LDD}{E_n \times W} \)

Where:

- **LL** = Initial lamp lumens
- **CU** = Coefficient of utilization
- **LLD** = Lamp lumen depreciation factor
- **LDD** = Luminaire dirt depreciation factor
- **E_n** = Average maintained level of illumination, footcandle
- **W** = Width of lighted roadway, feet

As this formula is usable in both the English and metric systems of measure, either units can be used. The resultant luminaire spacing will, of course, be obtained in units corresponding to the system units used.

In general, luminaires should be located along the right in the direction of travel.

On undivided highways and streets, the use of one-sided arrangements should be limited to pavement having overall widths of less than 1.25 times the mounting height.

**1140-4.3.4 Pole Location**

**1140-4.3.4.1 Lateral Placement**

See **L&D Manual Volume 1, Section 600** for lateral placement requirements. Where guardrail is not provided, the normal offset distance of the pole from the edge of pavement may be the same as if guardrail were provided if frangible bases are used in accordance with the latest AASHTO safety requirements.

For improved safety, where the typical section of the roadway will allow a greater setback, poles should be located farther from the pavement edge, consistent with available bracket arm lengths and frangible base capacities.

**1140-4.3.4.2 Bracket Arm Length**

Currently, conventional light poles are available with extended bracket arm lengths of 18, 20, 25 and 30 feet. These are in addition to the standard lengths of 4, 6, 8, 10, 12 and 15 feet. Poles with increased arm lengths should not be used intermittently except in unusual circumstances, such as may occur in a flare guardrail area in which the guardrail is not readily adjustable to accommodate the lighting units. In general, in the interest of consistency, increased setbacks should not be used for less than 5 or 6 pole spacings.

The bracket arm length should normally be no less than the pole offset; however, in certain situations such as on the inside of a sharp curve (i.e., on a loop ramp), better distribution will result from setting the light source slightly inside the vertical projection of the pavement edge. The actual bracket arm length and pole offset from the pavement should be established after a careful review of the pavement geometry.

Typical bracket arm lengths for given pole offsets from the edge of pavement can be found in **Table 1197-6**.

The following maximum combinations of bracket arm length and pole height are useful rule-of-thumb values for light poles mounted on aluminum transformer bases. Other combinations are possible but their feasibility must be verified by the designer with at least two manufacturers before including in the Plans.
1140-4.3.5 High Mast

ODOT projects scoped for high-mast lighting generally utilize 400 watt high pressure sodium fixtures mounted on 70-foot or higher poles. Fixtures may be symmetric (IES Type V), asymmetric (IES Type II or III), or asymmetric “long and narrow” (IES Type I). Each high-mast pole supports two to six luminaires in a symmetrical arrangement. See C&MS 725.21 for additional information on luminaires for light towers.

1140-4.3.6 Low Mast

An ODOT project utilizing a low-mast lighting system is made up of 50-foot poles supporting single 400 watt high pressure sodium fixtures. The fixture is generally symmetric (Type V) and is supported by a Style III or “shepherd’s crook” pole (see Traffic SCD HL-10.11) which is barrier-mounted between opposing lanes of traffic. This method is ideal for lighting sections of freeway with three to five lanes of traffic in each direction without the daytime “visual clutter” of twin-arm conventional units or the nighttime light trespass to areas adjacent to the roadway resulting from high-mast units.

1140-4.3.7 Decorative

Occasionally, a project will require the use of decorative poles and fixtures in order to maintain or establish the aesthetics of an area, such as replacement of a bridge in an area already utilizing fluted post-top units, or lighting the pedestrian/picnic areas of a rest area or Welcome Center.

Since most projects requiring decorative poles will be in an urban (i.e., curbed) area, the minimum offset to maintain 2 feet minimum lateral clearance from curb face will apply, with consideration given to overhead and underground utilities. Decorative post-top pole placement in the pedestrian/picnic area of a rest area varies with the individual layout, but an offset of 5 feet from the edge of the sidewalk is often used.

1140-4.4 Partial Lighting

1140-4.4.1 Interchange - General Information

Partial lighting is the process of lighting only the parts of the interchange that are considered most critical to the night driver. Partial interchange lighting implies that later stages of more fully developed lighting are not anticipated during the expected life of the initial system. Partial interchange lighting will generally apply in rural areas, and occasionally in suburban areas, to the lighting of interchanges on otherwise unlighted freeways for which ADT traffic satisfies warrants under Case PIL-1 or Case PIL-2 (see Table 1197-3). Lighting provided under this concept will generally be limited to diverging lanes, merging lanes and ramp intersections as described in the following section.

The following information is intended to provide guidance in determining the number and locations of lighting units for partial interchange lighting. The procedures outlined are generally applicable under the conditions stated; however, it does not necessarily follow that lighting at a given level will automatically be approved simply because conditions satisfy the warrants.

The typical luminaire arrangement for partial interchange lighting as shown in Figure 1198-3 should be used in the following situations.

1. All diverging roadways, including exit ramps, ramp divergences, directional roadways, etc., should be lighted, particularly in the gore point areas. Normally, four units will suffice for partial lighting; however, when the taper is shorter than the normal unit
spacing, the unit at the beginning of the taper may be omitted.

2. All converging roadways, including ramp acceleration lanes, ramp convergences, directional roadways and C-D roads, should be lighted. Normally, three units will suffice for partial lighting; however, the number of units may be adjusted in proportion to the taper length when it varies substantially from the standard 1200-foot ramp entrance length.

3. Combined accel-decel lanes (weaving lanes) should be lighted as combinations of the above two treatments. The seven units normally used may be adjusted to a fewer number depending on the length of the lane.

4. All ramp intersections with crossroads and all crossroad intersections within the general interchange area should be lighted in accordance with typical arrangements shown in Figure 1198-3.

In general, key unit locations for ramps are controlled by their speed change lanes and/or their intersections with side roads. However, overpasses and underpasses are not uncommon on ramps, and it will be necessary to adjust unit spacing in such cases to accommodate the various structure related items (see Section 1140-4.6). On partially lighted interchanges, the ramp proper is usually left unlighted for the initial installation; however, where loop ramps are involved, and the loop is entered from roads with high operating speeds, full loop ramp lighting may be provided.

The first unit on an exit ramp is normally placed 195 feet from the key unit on the deceleration lane. This normal spacing should be adjusted downward to provide a uniform spacing for the ramp units ahead. On curving ramps of short radius, for luminaires mounted on the inside of the curve, the spacing should be 0.55 times the normal straight line spacing; and for luminaires on the outside of the curve, the spacing should be 0.70 times the normal straight line spacing.

Where ramp merges with the mainline are gradual and space between the mainline and ramp pavements is limited, or where a narrow median not feasible for the location of lighting units is used to separate a collector-distributor road from a nominal two-lane directional roadway, the mainline must be lighted from units mounted along the right of the ramp (in the direction of travel) or C-D road. Under such circumstances, the ramp units should be at least of the same type, size and mounting height as the normal mainline units. Spacing for such units should be based upon a theoretical pavement width which includes the space between the merging pavements, i.e., the total width from the left edge of the mainline pavement to the right edge of the ramp or C-D road pavement.

Key unit locations for acceleration lanes or merging pavements should be at the point of the convergence of the right edge of mainline traveled pavement and the left edge of the subordinate traveled pavement (oriented in the direction of travel).

At deceleration lanes or diverging pavements, the key unit location should be 40 feet in advance of the transverse joint which ends the gore area traveled pavement.

Key unit locations for combined accel-decel lanes and for relatively short auxiliary lanes should be treated at each end in accordance with the above, and reference should be made above for lighting the mainline pavement from the right of the added lane.

When calculating lighting unit spacing along tapers or variable width pavement, the pavement width at the key location (as located in the above discussion) should be used to determine the spacing for the succeeding, or second, location. The spacing from the second to the third unit should be determined from the pavement width at the second unit position. The spacing from the third to the fourth unit should be determined from the pavement width at the third position, and so on, until the pavement width and the spacing become uniform.

The following procedures should be followed in establishing key unit locations and
1. Normally, the key unit location at the entrance nose for a ramp or merging lane will be installed in the future (see Figure 1198-3). The unit spacing to the second unit (or first unit to be installed initially) should be computed on the basis of the pavement width at the entrance nose. The spacing calculations should then be continued, as discussed previously in this section, proceeding toward the end of the acceleration taper, and alternating the initial and future units until the desired unit locations for the initial installations have been satisfied. If the entrance nose occurs on or immediately adjacent to a bridge, the nose unit should be installed initially, and the alternating of future and initial units as shown in Figure 1198-3 should be reversed (i.e., units labeled “F” should be installed initially, and vice versa).

2. For exit ramps or diverging lanes, the key unit should be installed initially at a point 40 feet in advance of the gore point as shown in Figure 1198-4. From this key unit location, spacing calculations should be continued toward the beginning of the exit taper, using the pavement width at the key location to determine the spacing to the second (future/full) location. Using the pavement width at that location as a basis for spacing to the next unit (future/full) location, the process should be repeated as necessary as previously discussed for tapered areas. The unit within the tapered area nearest the beginning of the taper should be installed initially, as shown in Figure 1198-4. Reference should also be made to Figure 1198-4 for location of the first mainline unit beyond the exit gore and for spacing along the ramp proper.

3. Lighting units at ramp intersections should be installed with the initial lighting project (see Section 1140-4.6.2).

4. Unit locations for future/full lighting on interchange separation structures or other major structures within the interchange area should be determined as discussed in Section 1140-4.6, and grounding, conduit, pilasters, etc., for these units should be provided with the initial bridge construction to facilitate the future addition of bridge lighting.

1140-4.4.2 Diamond Interchanges

An illustration of partial lighting applications to a basic diamond interchange is shown in Figure 1198-5.

1140-4.4.3 Partial Cloverleaf and Cloverleaf Interchanges

For the intersections to work safely they should be designed properly with channelization to discourage/prohibit wrong movements, adequate signing to reaffirm the design, and lighting to give the driver the ability to see the geometry of the intersection.

At partial cloverleaf interchanges, in addition to the merge-diverge areas and the intersections with the highway, critical points include the loop ramps.

Full cloverleaf interchanges generally do not involve partial lighting since most of the interchange is composed of critical areas.

1140-4.4.4 Intersection

Partial lighting will alert the driver to an approaching intersection. In general, all lighting units for intersections may be considered key units. Severely skewed intersections, or those having more than four approaches, will require special consideration to assure that the apron areas and traffic control devices are discernable at night and that appropriate lateral clearances are available in the interest of safety. Unit locations for the more common intersection types are as follows:

1. On two-lane road intersections, including T intersections, use two units - one to the right (in the direction of travel of the higher-volume road) and 40 feet beyond the far
edge of the intersecting pavement, or at the point of curvature (PC) of the far radius return of the intersecting pavement; and the other in a similar manner for the opposite direction of travel. These locations may require adjustment if the normal design spacing is exceeded (for a continuously lighted roadway) or if the light pole is to be used in combination as a support for traffic control devices.

2. Intersections on four-lane roads will generally require four units - one in each quadrant to the right (in the direction of travel) at the PC or 40 feet beyond the intersection, whichever is greater (the "intersection" is considered to be the theoretical point where the projected edges of the two pavement edges in a given quadrant would intersect).

3. At channelized intersections or where turning roadways are involved, such as at ramp intersections with multiple-lane side roads, lighting units should be located so as to illuminate protected turning lanes, approaches to divided areas or traffic islands, and at radius points as discussed above. Figure 1198-7 illustrates typical luminaire placement for intersections. Key unit locations in such situations may be similar to those discussed for merging and diverging pavement gores in Section 1140-4.4.1.

Using a single light source at an intersection is generally undesirable because it may create a “brightness barrier.” This “brightness barrier” is the same problem we experience when we attempt to see beyond the headlights of an oncoming vehicle. Multiple light sources at an intersection increase the lighted area and reduce the need to see beyond until the driver is inside the lighted area looking out.

1140-4.4.5 Combination Supports

In the interest of reducing costs and the number of support poles in intersection areas, light poles and traffic signal or overhead sign supports are often combined when practical. This practice is encouraged to minimize the clutter effect of numerous supports which could hamper sight distance and increase the opportunity for vehicle impact with obstacles.

The designer should always check with the maintaining agency of the traffic signals prior to combining signal/light poles. This is especially important if the lighting system is 480 volts. Many agencies do not desire signal maintenance crews working with live high voltage lighting cables in the signal poles, pull boxes and conduits. In this event, the designer should attempt to maintain at least 10 feet separation between signal and lighting supports for aesthetic reasons, if possible. If combination signal/light poles are to be used, the signal and lighting designer(s) should carefully locate the supports so as to satisfy traffic and lighting needs, such as pedestrian push button and signal indication locations, vehicular signal locations, mast arm length, luminaire location and bracket arm length.

1140-4.5 Full Lighting

1140-4.5.1 Interchange

On simpler interchanges, it is assumed that the driver will be able to visualize the layout of the interchange by viewing the critical points. When interchanges become more complicated such that the driver will need to be able to see the ramps, turning roadways, and the various elements of the interchange to get the visual picture, it may be necessary to light the entire interchange. This is known simply as complete or full interchange lighting. Full interchange lighting is generally associated with freeways and expressways where the mainline is lighted; however, it can be used in rural or suburban locations where there is a need to light the interchange, but not necessarily a need to light the mainline. In such instances, the need usually arises from the complex nature of the interchange.

With conventional lighting, luminaires are located at regular spacings along the ramps and turning roadways of the interchange. High-mast lighting is often used, especially at large or complex interchanges for the economic, safety and aesthetic reasons mentioned in Section 1140-4.2. High-mast unit locations vary with every interchange due to the geometrics; however, along the on and off-ramps, they are generally located on the outside (driver’s right side) of the ramp. At interchange intersection areas, the high-mast units are
usually best located inside the interchange.

The latest interchange configuration, the Single Point Urban Interchange (SPUI), generally utilizes full interchange lighting due to the extremely wide intersection area with the crossing arterial and the unfamiliar geometrics involved. High-mast units are ideal for this application.

1140-4.5.2 Street

Instead of partial lighting along a street (i.e., intersection lighting, as discussed in Section 1140-4.4.4), continuous or full street lighting may be required for a project. First, the pole arrangement and spacing must be determined based on the street width and illumination level, as discussed in Section 1140-4.3.3. The “one-side,” “staggered” and “opposite” arrangements (Figure 1198-8) are used when it is impossible or inadvisable to use a median-mounted configuration. The choice among the three options depends mainly on the width of the facility to be lighted. The “one-side” arrangement is for narrow, one-way streets; two-way, two or three-lane streets; and other situations where the street is no wider than one to one and a half times the mounting height of the luminaire. The “staggered” arrangement is for streets of medium width (one and a half to two times the mounting heights). The “opposite” arrangement is used for streets which are extremely wide and where medians are too wide to effectively accommodate median lighting. In this latter case, the arrangement is actually two independent “one-side” arrangements.

Once the arrangement and spacing have been determined, the critical or key units at the intersections are chosen as shown in Section 1140-4.4.4. Finally, the pole locations between intersections are determined based on the arrangement and calculated spacing, with minor spacing adjustments as needed.

1140-4.6 Specific Cases

1140-4.6.1 Exit and Entrance Gores

See Section 1140-4.4.1 for information about lighting exit and entrance gore areas.

1140-4.6.2 Intersections

In general, all lighting units for intersections may be considered key units. In the interest of reducing costs and the number of support poles in intersection areas, light poles, traffic signal, or overhead sign supports, are often combined when practical. This practice is encouraged to minimize the clutter effect of numerous supports which could hamper sight distance and increase the opportunity for vehicle impact with obstacles. Severely skewed intersections, or those having more than four approaches, will require special consideration to assure that the apron areas and traffic control devices are discernible at night and that appropriate lateral clearances are available in the interest of safety. Unit locations for the more common intersection types are as follows:

1. Two-Lane Road - On two-lane road intersections, including T intersections, use a minimum of two units:
   a. One to the right in the direction of travel on the higher-volume or through roadway, and 40 feet beyond the far edge of the intersecting pavement, or at the PC (point of curvature) of the far radius return of the intersecting pavement, and
   b. The other unit is placed in a similar manner for the opposite direction of travel.

   These locations may require adjustment if the normal design spacing is exceeded (for a continuously lighted roadway) or if the light pole is to be used in combination with a support for traffic control devices.

2. Four-Lane Road - Intersections on four-lane roads will generally require four units:
   One in each quadrant to the right in the direction of travel at the PC (point of curvature),
or 40 feet beyond the intersection, whichever is greater. The “intersection” is considered to be the theoretical point where the projected edges of the two pavement edges in a given quadrant would intersect.

3. Channelized Intersections - At channelized intersections or where turning roadways are involved, such as at ramp intersections with multiple-lane side roads, lighting units should be located so as to illuminate protected turning lanes, approaches to divided areas or traffic islands, and at radius points as discussed above. Key unit locations in such situations may be for merging and diverging pavement gores.

Also see Section 1140-4.4.4 for information about highway lighting at intersections.

1140-4.6.3 Bridges Over Highways

Light poles on overpasses should be located as near to piers as possible to reduce pole vibration, and midway between construction joints where feasible. If abnormal pole vibration is anticipated, consideration should be given to the use of special pole mountings such as pier cap extensions or other structural modifications; or special padding material may be desirable between the pole base and pilaster support to dampen the effect of vibration.

Lighting units should not be installed within approach slab areas, nor within 10 feet of approach slabs. When the length of the bridge and approach slabs, plus the 20 feet for approach slab clearance, results in a length less than the design spacing for the lighting, the lighting units should be located uniformly at each end of the structure. If a staggered arrangement is being used, the units should be located at the far end of the structure on the right in the direction of travel.

When the length of the bridge and approach slabs, plus the 20 feet for approach slab clearance, results in a length greater than the design spacing, the first lighting unit associated with the structure must be located at least 10 feet in advance of the beginning of the approach slab. Subsequent units should follow design spacing across the bridge. See Figure 1198-9 for overpass key unit locations.

1140-4.6.4 Pedestrian Bridges

Generally, all pedestrian bridges should be lighted. Since approaches to pedestrian bridges are not always accessible to maintenance vehicles, and since pedestrian bridge lighting is highly susceptible to vandalism, special consideration should be given to the location and protection of this type of lighting design.

1140-4.6.5 Overhead Signs

See Section 1140-3.5 for information about lighting overhead signs.

1140-4.6.6 Street Trees

Since many projects involve modifying the typical section of an urban or suburban roadway and include the replacement or addition of street lighting and street trees, coordination in the placement of the light poles and street trees is essential. The location and spacing of the light poles is of primary concern. Street trees can then be placed between pole locations with adequate spacing from lighting units to allow for the illumination of the pavement. Consideration should be given to mounting height, bracket arm length and type of tree, as well as the tree trimming maintenance issue.

1140-4.6.7 Underpasses

Underpass luminaires may be required beneath any structure whose transverse width (between outer edges of parapets) is 75 feet or more. For underpass lighting design purposes, twin structures having less than 40 feet between adjacent parapets should be
considered as a single structure. When the separation between twin structures is between 40 and 60 feet, consideration should be given to the use of post-mounted underpass units located between the two structures at a mounting height of approximately 20 feet.

Occasionally, skewed structures less than 75 feet in width will require underpass units, especially where the omission of such units would result in a serious compromise of the uniformity criteria. Underpass lighting may be required when a structure prevents adjacent roadway units from providing lighting on the roadway beneath the underpass to the average intensity and uniformity of that provided for the roadway outside of the underpass. Each underpass must be evaluated on its own merits. However, installations employing luminaire mounting heights of 50 feet or less with underpasses whose length (structure width) is less than 1.5 times the luminaire mounting height and which are located in the middle third of the space between the roadway luminaires will not normally require underpass lighting units.

Adjacent underpasses may be located in such proximity that the roadway beneath the underpass structures must have supplemental lighting during daylight hours. In these cases, guidance will be found in the IES's Recommended Practice 22 (RP-22). This possibility should be considered when the length of the underpass exceeds 80 feet.

When underpass luminaires are not required, and the conventional unit mounting height exceeds the vertical clearance of the structure, lighting units should be provided in advance of and/or beyond the outer edge of the parapet of the overpassing structure at a distance conforming with the following conditions:

<table>
<thead>
<tr>
<th>Mounting Height Feet</th>
<th>Distance from Light Unit to Parapet Feet</th>
</tr>
</thead>
<tbody>
<tr>
<td>32.5</td>
<td>40</td>
</tr>
<tr>
<td>40</td>
<td>60</td>
</tr>
<tr>
<td>50</td>
<td>90</td>
</tr>
</tbody>
</table>

When a staggered arrangement is used, luminaires should be located to the right in the direction of travel at the exit end of the underpass.

When the above separation distance cannot be provided, the designer should check the need for glare shields to protect the overpassing traffic.

When underpass luminaires are used, their effect should be considered relative to adjacent conventional units, and distances between the overpassing structure parapets and the nearest conventional units should be established accordingly.

When the overpassing structure clearance is greater than the mounting height, conventional highway light poles may be used under the structure, or the units may be mounted on piers or abutments. Under such circumstances, the above distances need not apply. See Figure 1198-10 for underpass key unit locations.

1140-4.6.8  Tunnels

Planners and designers should review Section 1103-6.9, Underpasses and Tunnels, for definitions, warrants, and other information related to tunnels. The goal of tunnel lighting is to provide for good driver visibility and a safe environment within a tunnel, day and night. The many factors that contribute to or detract from visibility need to be identified and their specific importance determined for each tunnel. The factors include:

1. Characteristics of the roadway approaches.
2. Characteristics of the tunnel roadway, walls and ceiling.
3. Characteristics of the area surrounding the tunnel portal.
4. Atmospheric and environmental conditions.
5. Characteristics of vehicular traffic operations.
6. Orientation of the tunnel with respect to sun and sky.

Since the need for design of tunnel lighting is relatively rare in Ohio, the designer should reference the ANSI/IES Tunnel Lighting (RP-22) publication for an in-depth discussion on how these factors relate to each other. The publication contains information that will assist in determining lighting needs, providing solutions and evaluating resulting visibility within vehicular roadway tunnels.

1140-4.6.8.1 Tunnel Lighting Design Guidance

Tunnel lighting design is done using luminance criteria (units of cd/m²) instead of the illuminance criteria (units of fc) typically used by ODOT for lighting design on open roadways. Designers should be aware that luminance-based tunnel design usually requires special software (e.g., AGi32™) not commonly used for open-roadway lighting design.

The following list includes specific design guidance for tunnel lighting design on ODOT projects. Contact the Office of Roadway Engineering for additional guidance.

A. An early step in tunnel lighting design is to obtain the required threshold luminance level (Lth). RP-22 gives several methods for this in Part 6.4.
   a. For short tunnels, the use of RP-22 Part 6.4.1, which determines preliminary design Lseq and Lth values, will often be acceptable to ODOT as a final design value as well.
   b. For long tunnels, the more involved RP-22 Part 6.4.2 method of determining Lseq should be used. Essentially, the designer first calculates an equivalent veiling luminance (Lseq) for the general area seen by the driver approaching the tunnel under worst-case (bright sun) conditions. Next, Lth is obtained by multiplying Lseq by a ratio. The ratio value is determined by a subjective criterion known as the Safety Rating Number (SRN). Note that ODOT recommends the use of SRN = 5.

B. Long tunnels are rare in Ohio. However, if the tunnel is long, then following the threshold lighting zone will be one or more additional lighting zones of gradually decreasing design luminance values. RP-22 Part 6.4.3 presents two methods for calculating the transition zone luminance values, either of which are acceptable to ODOT, but the Step-Down Method is preferred.

C. Choose the nighttime luminance levels per RP-22 Part 6.4.5.

D. Some tunnels require switching steps that vary the internal luminance in response to the external luminance changes created by the weather and changes in the position of the sun. The following guidelines apply to ODOT projects:
   a. Provide a PLC conforming to ODOT Supplemental Spec 818 for the control system.
   b. Provide a control system enclosure conforming to ODOT Supplemental Spec 820. Locate the enclosure in an area that will not be in direct sunlight or provide a shelter, because the enclosure is passively cooled (unless active cooling is approved by ODOT). Provide all conduit entries with O-ring sealed hubs.
   c. Obtain entrance portal measurements with one or more luminance meters compatible with the PLC inputs. An analog output is preferred, and this signal should be filtered and appropriately time-averaged at the PLC.
   d. Dim tunnel luminaires using a 0-10VDC dimming signal obtained from the PLC. Buffer the signal as necessary. Provide a separate control signal for each zone.

E. Provide communications conforming to Supplemental Specification 809 for monitoring the tunnel conditions. The set of tunnel condition parameters that require remote monitoring will vary from project to project. Contact the Office of Traffic Operations, ITS Section, for additional guidance.
a. The preferred method of monitoring tunnels that do not have fire alarm control panels is by CCTV. Unless the tunnel is short enough for the CCTV camera to see completely through, provide a CCTV camera at each entrance and exit portal.

b. For tunnels equipped with fire alarm control panels, coordinate with the District and any other authority having jurisdiction (AHJ) to determine communication requirements for the project. See also NFPA 502, Part 4.5.

F. If used, provide conduit bodies made of cast steel or malleable iron, with wedge-type malleable iron cover (not sheet steel), both triple-coated (electroplated or hot-dip zinc base coat, chromate intermediate coat, and epoxy finish coat), neoprene seal material, and all stainless steel hardware.

G. Provide metal conduit per NFPA 502 Part 12.3.1. If stainless steel conduit is not specified, provide Rigid Metallic Conduit per ODOT CMS 725.04. Exposed PVC conduit is not permitted in tunnels, per NFPA 502 Part 12.3.2.

H. Assure all electrical devices used in exposed areas are UL-Listed for Wet Locations.

I. Assure that all electrical and electronic devices in exposed locations operate over the following environmental conditions, within their respective enclosures:
   a. Temperature: -30°F to +165°F.
   b. Humidity: 0-100% RH.

J. Assure all circuit breakers are labeled for 100% load continuous use.

K. Do not locate luminaires or junction boxes directly under roof joints because the joints sometimes leak.

L. Provide LED tunnel lighting, emergency lighting and auxiliary lighting conforming to Supplemental Specification 813.

M. Assure that the lowest point of each conduit run is equipped with a conduit drain with a stainless steel screen, except drains located in areas subject to wash-down, which shall be rated NEMA 4X or IP66. Long horizontal conduit runs shall be equipped with such drains at a spacing not to exceed 50 feet and located on a short stub below the run.

N. Assure that each electrical pull box or manhole located above the tunnel level is equipped with a drain conduit routed to a suitable protected outlet location not subject to damage by mowers and other sources. Provide a varmint screen at the conduit drain outlet. Locate the outlet at least 1.5 feet above the bottom of a ditch, wall, slope or swale, or route to a suitable roadway drainage conduit. For conduit drain outlets in ditches, slopes or swales, install a 12-inch square flat-panel marker sign on two U-channel posts that straddle the conduit at the outlet, to help locate and protect it. The sign message shall be "CONDUIT DRAIN" in 2-inch green letters on a white field using 730.18 Type F sign sheeting, with a 1-inch green stripe across the top, and facing the roadway. Mount the bottom of the sign panel at least 5 feet above grade.

1140-4.6.8.2 Tunnel Fire Protection Design Guidance

Tunnels shall conform to NFPA 502, Road Tunnels, Bridges, and Other Limited-Access Highways, including all documents referenced therein. NFPA 502 provides fire protection and life safety requirements for tunnels. If a fire alarm system is required by NFPA 502 or other project documents, then designers should pay particular attention to NFPA 72, National Fire Alarm and Signaling Code, and NFPA 70 (NEC) Article 760, Fire Alarm Systems.

Because tunnel fire-protection system and tunnel lighting design tasks are interrelated, this section of the Traffic Engineering Manual lists a number of fire-protection design guidelines below.

A. The fire alarm control panel enclosure will be separate from the tunnel lighting control system enclosure.
   a. Do not locate the enclosure in direct sunlight or mount directly to a wall.
   b. Provide all conduit entries to the enclosure with O-ring sealed hubs.
c. Equip the enclosure with a vent-drain placed in the lowest point of the enclosure.
d. Do not mount enclosures containing electrical or electronic components, switches, shunts, or similar devices susceptible to internal condensation directly onto concrete walls. Instead, the designer should specify suitable concrete anchors and standoffs to leave at least one inch of air space between the enclosure and the wall. Provide stainless steel standoff hardware.
e. Do not expose any touch-panel or monitor screens directly to the weather; provide a transparent, snap-latch, weather-tight UV-resistant access door.
f. Provide external labels of 630.02 Reflective Sheeting, Type F, silk-screened, with red letters on white background.

B. If used, provide conduit bodies made of cast steel or malleable iron, with wedge-type malleable iron cover (not sheet steel), both triple-coated (electroplated or hot-dip zinc base coat, chromate intermediate coat, and epoxy finish coat), neoprene seal material, and all stainless steel hardware.
C. If stainless steel conduit is not specified, provide Rigid Metallic Conduit per ODOT CMS 725.04.
D. Provide stainless steel clamps and hardware for all conduit wall and ceiling attachments.
E. Unless specified otherwise, use linear heat detector cable for automatic detection.
   a. Provide stainless steel hanger hardware for linear detectors. Route all linear detector cable direction changes as gradual sweeps conforming to the manufacturer’s bend specifications.
   b. Provide stainless steel junction boxes conforming to Supplemental Specification 820 for all linear detector circuits. Do not locate any junction boxes over traveled lanes.
   c. Provide all locking enclosures (including test shunts) with a stainless steel latching hardware and marine brass lock core with weatherproof tab.
   d. Provide O-ring sealed hubs for all conduit entries into junction boxes.
F. Provide LED alarm indicators for each manual fire alarm box. Provide stainless steel wall supports at each end of any conduit used to mount indicators directly to the manual fire alarm box.

G. Traffic control and ITS construction items (beacons, signs, dynamic message signs, etc.), used to control traffic approaching the tunnel portal and direct approaches, shall meet all applicable sections of the ODOT CMS, in particular Parts 625, 630, 631, 632, 633, Supplemental Specification 809, and other Supplemental Specifications as required.
H. Water supply construction items shall meet the requirements of the Authority Having Jurisdiction (AHJ) and ODOT CMS Part 638.
I. Designers shall pay particular attention to NFPA 502 Chapter 12, Electrical Systems during all stages of electrical system design.

1140-4.6.9 Median Mounted

When median-mounted lighting is used, the system will require supplemental units along the outside of the roadway when the effective width of the directional pavement is excessive. For example, if the directional pavement exceeds 48 feet, and a 40-foot mounting height is used, supplemental units will be needed; or if the directional pavement exceeds 60 feet and a 50-foot mounting height is used, supplemental units should be added.

High-mast units can also be very effective along freeways when median mounted, either in a grass median with proper lateral clearance or barrier mounted.

1140-4.6.10 Roundabouts

All roundabouts shall be lighted. Roundabout lighting shall be designed according to IES DG-19-08, Design Guide for Roundabout Lighting, published by the Illuminating Engineering Society. In general, ODOT-maintained roundabouts shall have lighting design limits extending beyond the approach tapers, as shown in IES DG-19-08 Figure 3.
Typical installations shall have a minimum of eight pole locations: four illuminating the circulatory roadway and pedestrian areas and four illuminating the approach tapers. Design lighting levels and uniformity shall comply with IES DG-19-08 Table 1, which is based on functional class of the intersecting roadways and pedestrian demand. This Table is reproduced below.

<table>
<thead>
<tr>
<th>Functional Classification</th>
<th>Maintained Average Horizontal Illuminance in Lux/fc on the Pavement Based on Pedestrian Area Classification</th>
<th>$E_{avg}/E_{min}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Major/Major</td>
<td>High: 34.0/3.4, Medium: 26.0/2.6, Low: 18.0/1.8</td>
<td>3:1</td>
</tr>
<tr>
<td>Major/Collector</td>
<td>High: 29.0/2.9, Medium: 22.0/2.2, Low: 15.0/1.5</td>
<td>3:1</td>
</tr>
<tr>
<td>Major/Local</td>
<td>High: 26.0/2.6, Medium: 20.0/2.0, Low: 13.0/1.3</td>
<td>3:1</td>
</tr>
<tr>
<td>Collector/Collector</td>
<td>High: 24.0/2.4, Medium: 18.0/1.8, Low: 12.0/1.2</td>
<td>4:1</td>
</tr>
<tr>
<td>Collector/Local</td>
<td>High: 21.0/2.1, Medium: 16.0/1.6, Low: 10.0/1.0</td>
<td>4:1</td>
</tr>
<tr>
<td>Local/Local</td>
<td>High: 18.0/1.8, Medium: 14.0/1.4, Low: 8.0/0.8</td>
<td>6:1</td>
</tr>
</tbody>
</table>

1140-4.7 Placement Adjustments

Once all pole locations have been determined for a given design area, individual poles may require slight adjustment longitudinally or laterally to avoid interference with utilities, minor structures (e.g., catch basins, headwalls), drive aprons and ditches. In urban areas where building faces are often at the back of the sidewalks, attention should also be given to doorways to buildings, overhead canopies and signs, basements and utility vaults under sidewalk areas, and heated sidewalks. Such adjustments should normally not exceed a 5 to 6-foot shift per location.

1140-5 Circuit Design

1140-5.1 General

Proposed circuitry, including service pole locations, is a basic requirement of any lighting system. The following sections reflect general ODOT standard materials and methods; however, the lighting designer should always check with the specific District (or local maintaining agency) for confirmation of standards or preferred alternate materials and/or methods.

1140-5.2 Voltage

1140-5.2.1 General

Generally, lighting systems maintained by ODOT are 480-volt systems. Occasionally, stand-alone intersections utilizing combination poles will be lighted using 120 volt fixtures. If the maintaining agency is other than ODOT, the system voltage must be determined early in the design process.

1140-5.2.2 Voltage Drop

After formal approval of proposed service pole locations has been obtained from the power supplying agency and the proposed lighting layout has been approved by ODOT for detailed design, voltage drop calculations should be completed and included in the Stage 3 review submittal. The calculations should indicate the voltage at each lighting unit, at each lighted sign installation, at each “wye” in each circuit, and at the end of each circuit.

The allowable voltage drop in each circuit is 5 percent. Reference should be made to Figure 1198-12 for a sample voltage drop calculation for a 480-volt, two-wire grounded neutral system (current ODOT standard is 480-volt, three-wire grounded neutral but the voltage drop calculation method is unchanged.).
1140-5.3 Control Center

1140-5.3.1 General

The principle type of lighting control center used by ODOT is the pole-mounted type with the photoelectric control mounted near the top of the wood pole. The designer should contact the individual District (or maintaining agency) to determine if a meter is required.

1140-5.3.2 Load

As part of the construction plan preparation, the designer should include a Control Center Data chart (Figure 1198-11) with all the required information. Details of the enclosures and how they are wired and mounted are shown in the Traffic SCD HL Series.

Designers should limit lighting branch circuit loads to 30A or less, if possible, to allow wires to be terminated and bent into position in the support base volume. Up to six (6) branch circuits can emanate from a typical HL-60.31 Lighting Control Center. Designers should strive to use no larger than #2 AWG in branch circuits, if possible. See 1140-5.4.2.

1140-5.3.3 Location

Service facilities should be located outside interchange areas, but within right-of-way limits. Where safety criteria applies, the supporting poles should be located more than 30 feet from the edge of the traveled pavement. Special care should be taken in the location of service facilities to assure reasonable accessibility by maintenance personnel and equipment during wet weather. Areas such as at the toe of a steep slope below the access roadway and deeply swale areas should be avoided, especially if they are subject to temporary flooding or drifting snow. Cross section data and right-of-way information shall be examined for each service pole and control center location to facilitate evaluation of its suitability relative to adjacent terrain. Each location shall also be formally cleared with the power supplying agency, and copies of all correspondence relative to electrical service shall be furnished to the District reviewing the lighting plan. During the initial contact with the power supplying agency, special offset requirements for service poles should be discussed, the supplying agency's system power requirements should be determined, and policies with respect to secondary lightning arrester locations, grounding, metering, etc., should be clearly understood. Where local governmental agencies require that service pole areas be enclosed by fence, the designer should determine if grounding of the enclosure fence is required.

1140-5.4 Cable

1140-5.4.1 General

All new or completely replaced lighting systems maintained by ODOT shall be three-wire systems utilizing distribution cable rated at 2400 volts. On projects that are within existing lighting systems, the new distribution cable should match the existing distribution cable.

1140-5.4.2 Cable Size

The preferred size of circuit cable is No. 4 AWG. If necessary to avoid an excessive voltage drop, larger cable may be used between the control center and the first lighting unit within a given circuit. If this procedure still results in a voltage drop exceeding 5 percent, the circuit cable size should be increased to No. 2 AWG, or larger in rare instances. Uniformity in circuit cable size and type of connector kit is highly desirable in a given project area. Reference should be made to Section 1140-5.2.2 for documentation requirements for circuitry voltage drop calculations.

Pole and bracket cable, used and itemized separately with conventional units, should be No. 10 AWG and extends from the connector kits in the pole base to the lighting fixture.
1140-5.4.3 Cable Type

There are two types of circuit cable, distribution cable and duct cable. Distribution cable is single conductor wire with polyethylene insulation, while duct cable is a factory preassembled cable in a coilable, high-density polyethylene pipe-type duct (typically 1.5-inch diameter) with the specified number and size of insulated conductors.

1140-5.4.4 Cable Applications

Duct cable is often used within an interchange area since it is easily installed, cost efficient, and there is generally a reduced risk of it being disturbed since the interchange is within limited access right-of-way. Duct cable is generally not used along a highway where sign post installation, utility work, plantings and new curb/driveway cuts are apt to damage the cable.

Distribution cable is installed in conduit (Section 1140-5.5) along highways, under streets and ramps, and through bridges and concrete barrier.

1140-5.5 Conduit

1140-5.5.1 Conduit Type

Buried conduits should generally be rigid ferrous metal without encasement, including those which are specified for embedment in structure concrete; however, under the following conditions, buried conduits should be concrete encased:

1. Between primary service sources and distribution transformers.
2. Circuit interconnections on embankment slopes adjacent to separation structures.
3. On any slope steeper than 3:1.

1140-5.5.2 Conduit Size

The a list of conduit sizes appropriate for the usage indicated can be found in Table 1197-7; however, the nominal size may be increased where necessary to provide adequate space for the circuitry proposed.

1140-5.5.3 Conduit Fill

The required conduit size is determined by the number and sizes of cable to be contained in the conduit. The conduit should not be filled to more than 40 percent. The fill areas are determined by adding the cross-sectional areas of all cables to be contained in the conduit and compared to the 40 percent fill area of the conduit.

1140-5.6 Splice Types

1140-5.6.1 Connections Unfused Permanent

Connections unfused permanent are used in pull boxes to splice circuit wires together in the following situations:

1. Where a circuit branches.
2. Where a circuit enters the pull box adjacent to a lighted sign installation.
3. Where a circuit must change from duct cable to distribution cable (e.g., on either end of a structure and at the base of the service pole).

Although the connections are water resistant, connections in pull boxes should be kept to a minimum due to the inherent moisture problems which result.

1140-5.6.2 Connections Non-Permanent

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Connections of several types, are described in C&MS 725. The most routinely used connections are the fused and unfused pull-apart types, used to connect circuit cable with the pole and bracket cable in a conventional or post-top light pole base.

1140-5.7 Pull Box

1140-5.7.1 General

The ODOT standard pull box is detailed on Traffic SCDs HL-30.11. The 18-inch diameter pull box is intended for one circuit or for a maximum of three connections; and the 24-inch diameter pull box is intended for two or three circuits, or for a maximum of six connections. If more than three circuits are involved, consideration should be given to the use of two boxes or a box of special design. Pull boxes, when used, are generally located within the alignment of the normal longitudinal trench.

City standard pull boxes may be used where consistent with the practices and policies of the maintaining agency.

In general, the use of pull boxes is discouraged because experience has indicated that inherent moisture problems results in more disadvantages than advantages. If flow lines within approximately 20 feet of a pull box location will permit drainage, a positive drainage system using 4-inch shallow underdrains, should be installed.

1140-5.7.2 Pull Box Types

The ODOT standard pull box is concrete (C&MS 725.08); however, plastic (C&MS 725.07) may be used in urban lawn areas where there is no chance of vehicles driving over the box. Steel pull boxes, although used in highway and interchange areas in the past due to their low cost, are no longer used because of the lids being difficult to secure in place. The pull box then fills with water and debris and/or becomes a safety issue with mowing equipment and maintenance personnel.

1140-5.7.3 Placement

Acceptable locations for pull boxes are as follows:

1. At the base of a pole used to mount a control center or disconnect switch, if located lower than the roadway proper.
2. At each end of a structure which carries electrical utility lines across the structure (approximately 10 feet beyond the ends of the parapet).
3. At the conduit riser for underground lighting circuits.
4. For connection of illuminated signs or underpass lighting to a lighting circuit.
5. At any split or tap in a lighting circuit that cannot be provided in the transformer base of a light pole.
6. At a minimum, at one end of a conduit jacked under pavement.

In urban areas, the designer should avoid placing pull boxes within curb ramps, curb ramp landing areas, or too close to intersection radii where large turning vehicles will disturb the pull box or cover.

1140-5.8 Junction Box

Junction boxes, as detailed in Traffic SCDs HL-20.13 and HL-20.14, are intended for use in concrete barrier and on structures, respectively. The designer should check with the District before using them. There is some concern that unless structure junction boxes are required for cable pulling purposes due to an excessively long conduit run (in excess of 300 to 400 feet), junction box lids end up missing because of screws becoming loose, and screws lost or not replaced during maintenance operations. The box becomes an easy access point for water, rodents and debris.
1140-5.9 Trenching

1140-5.9.1 General

The normal longitudinal trench alignment for distribution cable or duct-cable installations will be parallel to the controlling pavement edge or base line and in a direct line from pole to pole, as detailed on Traffic SCD HL-20.11.

1140-5.9.2 Trench in Paved Areas - Jacking

When circuits require crossing under existing ramp, mainline or arterial pavement open to traffic, steel conduit (3-inch minimum diameter) is often jacked or pushed under the pavement to minimize disruption to traffic and the pavement itself. Push pits must be dug behind guardrail or beyond the back of the paved berm, as shown on Traffic SCD HL-30.22. Concrete pull boxes are usually installed at the ends of the jacked conduit for cable splicing purposes.

1140-5.9.3 Trench in Paved Areas - Open Cut

The alternative to jacking conduit under pavement is laying conduit in an open cut trench. This method is used when conditions are such that finding areas for push pits is difficult because of numerous utilities, right-of-way constraints, walls, sidewalks, etc., or if construction phasing is such that traffic can be satisfactorily maintained when trenching. In paved areas either a T trench or “narrow slit type” trench is used as shown in Traffic SCD HL-30.22. The cost of open cut trench (including conduit and replacement backfill and pavement) is generally one-third more than jacking the same size conduit.

1140-6 Foundations

1140-6.1 Foundation Types

1140-6.1.1 Conventional

1140-6.1.1.1 General

The standard conventional light poles is a transformer base type. All poles located within 30 feet of the edge of traveled pavement shall include a cast aluminum transformer base meeting current AASHTO safety requirements for frangibility, with the following exceptions:

1. Poles located along streets or roadways with design speeds less than 40 miles per hour and with adjacent pedestrian traffic shall be mounted on steel transformer bases.
2. High-mast (tower) poles, and light poles mounted on concrete barrier medians or certain walls and structures, shall be anchor base types.
3. Light poles located on bridges shall have steel transformer bases.

1140-6.1.1.2 Drilled Shaft

Since roadways are normally constructed on stable subgrades, foundations for conventional light poles may be designed for the following minimum depths unless unstable soil conditions are suspected:
<table>
<thead>
<tr>
<th>Light Unit Mounting Height Feet</th>
<th>Min. Foundation Depth Feet</th>
</tr>
</thead>
<tbody>
<tr>
<td>Less than 40</td>
<td>6</td>
</tr>
<tr>
<td>40 - 44</td>
<td>8</td>
</tr>
<tr>
<td>45 - 55</td>
<td>10</td>
</tr>
</tbody>
</table>

1140-6.1.1.3 Median Mounted

Conventional light poles mounted on concrete barrier median shall be anchor base poles. The poles shall have drilled shaft foundations as shown above except that the depth shown shall be the depth extending below the base of the median barrier. The SCDs show additional details.

Traffic SCD HL-10.15 is available for use on projects where the height of an existing concrete median barrier is being increased by at least 8 bolt diameters. It allows for the extension of existing anchor bolts using a coupling nut. This drawing does not constitute a general foundation and/or anchor bolt repair method; such methods shall be developed on a project-specific basis by a qualified structural engineer.

1140-6.1.1.4 Pilasters

Conventional light poles mounted on a bridge shall have steel anchor bases and are mounted on a projection beyond the normal outside face of parapet, or pilaster. Poles on pilasters should be located as near to piers as possible to reduce pole vibration. Where fencing separates the lighting pilaster from the bridge proper, a suitable handhold should be provided in the fencing to allow access to the pole handhole.

1140-6.1.2 High Mast

1140-6.1.2.1 General

Since light towers are usually located more than 30 feet from the traveled roadway, it is unlikely that the compaction for the roadway would have the same influence as for conventional light pole sites. Consequently, the design of foundations for towers will require a procedure involving soil classification at the site. Where soils profiles and/or reasonably accurate soils data are available from existing highway plans or other reliable sources, the soil classification and related foundation design process may proceed without the need for individual soil borings at each proposed site. However, designers are expected to exercise prudent engineering judgment in the event there is reason to suspect that existing soils information is not reliable for the tower site or if the information available indicates that the allowable lateral soil resistance is not compatible with design guide tables and charts. In such cases, individual soils borings should be obtained for each tower site which is suspect, and specific designs should be prepared for each tower foundation.

Reference should be made to the suggested procedure for light tower foundation design in Section 1140-8. This procedure is applicable to projects where reasonably reliable soils data is available.

1140-6.1.2.2 Maintenance Platforms and Grade Flattening

Maintenance platforms and grade flattening have been found to be traps for debris. The steepened slopes above and below the flattened area or the diversion of water along the wall of the platform are sources of slope erosion. These areas also require the manual trimming of vegetation since chemical control only leaves bare ground which is even more susceptible to erosion. These negative aspects and the resulting increased maintenance are more detrimental than the nicety of the flat area about the
base of the high-mast lighting unit. Therefore, the use of these features is no longer recommended.

### 1140-6.1.2.3 Median Mounted

Light towers mounted on, or more correctly, incorporated into, concrete barrier median are treated similar to overhead sign supports. Their foundation size (usually 36-inch diameter) requires a widening of the median barrier by use of 40-foot transitions as shown in the Roadway SCDs. When considering median-mounted tower lighting, the designer must consider the shoulder width on either side of the median. An adequate width shoulder must be available for the maintenance vehicle and the lowering of the luminaire mounting ring.

### 1140-6.1.3 Low Mast

#### 1140-6.1.3.1 General

Generally, low-mast lighting (defined as a single high-mast luminaire or as a dual-high mast luminaire (2-foot offset) mounted on a pole with a 50-foot nominal mounting height) requires a 2-foot diameter by 10 feet deep foundation in non-sloping areas. Deeper foundations should be considered in steeper sloping areas or areas of poor soils.

#### 1140-6.1.3.2 Median Mounted

Low-mast units are frequently mounted on concrete barrier median separating two-lane groups of traffic each having three or four lanes plus shoulders. The anchor base units utilize a rectangular pole base plate mounted on top of 50-inch barrier. The foundation extends 10 feet minimum below the base of the barrier as detailed in Traffic SCD HL-20.13.

### 1140-6.1.4 Decorative

Decorative poles should be looked at on an individual basis when determining foundations. Often, the standard 6, 8 or 10-foot depths can be used for poles 50 feet in height or less with possible modifications of the formed top 6 inches to accommodate larger decorative bases or sidewalk paver areas. Foundations for decorative units over 50 feet in height should be determined by a soils engineer furnished with soils information, pole heights and luminaire weights, quantities and effective projected areas.

### 1140-6.2 Locations

#### 1140-6.2.1 Conventional

Along uncurbed sections of roadway, the normal location of conventional light poles is 6.5 feet behind the face of guardrail. Where guardrail is not provided, the normal offset distance of the pole from the edge of pavement should be the same as if guardrail were provided, and frangible bases should be used in accordance with the latest AASHTO safety requirements.

In curbed areas, the normal location of conventional light poles is 2.5 feet behind face of curb (2 feet minimum clear), but no closer than adjacent utility poles near the curb.

For improved safety, where the typical section of the roadway will allow a greater setback than normal, poles may be located farther from the pavement edge, consistent with available bracket arm lengths.

#### 1140-6.2.2 High Mast
1100 HIGHWAY LIGHTING

1140-6.2.2.1 General

High-mast units must have 30 feet minimum clearance from the edge of pavement/traveled way (i.e., painted edge line) on freeways and expressways in the absence of guardrail. A 40-foot clearance is preferred if maintenance access is not compromised. The designer should be aware of culverts, ditches, fences, right-of-way/limited access limits, and underground and overhead utilities when selecting high-mast pole locations. Guardrail should not be installed solely to “protect” a high-mast unit unless absolutely necessary as the guardrail itself becomes an object for road users to strike. If guardrail or concrete barrier will be required to protect bridge columns or overhead cantilever or truss signs, the guardrail may be extended no more than 75 feet to include a high-mast pole.

1140-6.2.2.2 Maintenance Platforms

The use of maintenance platforms is discussed in Section 1140-6.1.2.2 When used, the clearance from the edge of pavement to the nearest edge of the platform wall must conform to the minimum offsets in the ODOT L&D Manual Volume 1.

1140-6.2.3 Low Mast

Unless mounted on concrete barrier median, low-mast units may be mounted on breakaway transformer bases or anchor bases, in which case, offsets must comply with those described for conventional poles (Section 1140-6.2.1) or high-mast poles (Section 1140-6.2.2) as appropriate.

1140-6.2.4 Decorative

Since most projects requiring decorative poles will be in an urban (i.e., curbed) area, the minimum offset to maintain 2 feet minimum lateral clearance from curb face will apply, with consideration given to overhead and underground utilities. Decorative post-top pole placement in the pedestrian/picnic area of a rest area varies with the individual layout, but an offset of 5 feet from the edge of the sidewalk is often used.

1140-7 Grounding

1140-7.1 Towers

Two ground rods are required (and separately itemized in the plan) for each high-mast pole. The second ground rod is associated with the lightning protection system required with each tower.

1140-7.2 Conventional

1140-7.2.1 General

All conventional, decorative and low-mast poles require one ground rod. This includes poles mounted on concrete barrier median. Details for pole grounding are shown on Traffic SCDs HL-20.11 and HL-20.13 (median mounted).

1140-7.2.2 Pilasters

Poles mounted on bridge pilasters are grounded via grounding bushings in the steel conduit to interconnect structure conduit system with structure grounding system. Traffic SCDs HL-20.14 and HL-50.21 provide details.

1140-7.3 Bridges

A structure grounding system (described in C&MS 625.16 and detailed in Traffic SCD HL-50.21) shall be paid with each bridge as part of the lighting plan quantities. Although the
structure grounding system pay item is composed of several ground rods, cable, etc., the callout location on the lighting plan for the pay item is at the centerline station of a fixed pier.

1140-7.4 Fences

Where overhead power lines cross a fenced roadway right-of-way, or where overhead transmission lines rated 110 KV or higher are parallel to roadway fences and the transmission line easement is contiguous to the roadway right-of-way, the roadway fences shall be grounded as shown and described on Traffic SCD HL-50.11.

1140-8 Suggested Procedure for Light Tower Foundation Design

The following information is intended to be used in determining caisson lengths for tower foundations without the need for an extensive soil investigation at each tower location.

Regardless of the type of foundation used, information on soil classifications and soil strengths which resist the lateral movement must be established for the foundation design and also to determine the lateral soil pressure. In most cases the subsurface investigations and soil borings made for the Project Soils Profile and bridges will be sufficient to determine the soils classification and strength. However, the determination of soil parameters should be made by a soils engineer. If the soil strength and classification are relatively uniform on a given project site, one value for lateral soil pressure can be used, and the need for extensive soil investigations at each tower location can be avoided. Recommended lateral soil pressure values are shown on Table 1197-9.

In addition to the lateral soil pressure, load reactions on the tower, horizontal shear, uplift and overturning moments shall all be taken under consideration when designing foundations. The foundations shall be designed for loads equal to, or greater than, the maximum loads of the tower design, with considerations given to economics and construction feasibility.

Design calculations to determine load reactions and horizontal shear on light towers shall comply with applicable AASHTO requirements as set forth in the latest issue of Standard Specifications for Structural Supports for Highway Signs, Luminaires, and Traffic Signals, except that the design wind load shall be based on wind speed of 90 miles per hour, with a maximum load of six luminaires, each weighing 75 pounds (35 kilograms), with a maximum actual projected area of 3.5 square feet and mounted in one horizontal plane.

When the values for allowable lateral soil pressure, total lateral force, and total moment about the resisting surface of the tower have been determined, the required embedded depth can be found using the Foundation Embedment Nomograph in Table 1197-10, which is based on E. Czerniak’s recommendations for lateral soil pressure of various soil strengths and classifications. This nomograph satisfies foundation criteria currently used for Ohio designs and is valid for caisson type foundations where the embedded depth does not exceed ten times the foundation diameter.

Values for lateral force and overturning moment must be adjusted to a value per foot of caisson width prior to using the nomograph. The normal tower foundation diameter shall be 36 inches unless the tower anchor base plate and bolt circle requires a diameter of 42 inches.

Since the foundation embedment obtained from the nomograph is the depth below the resisting surface of the earth and not from the ground line, the total required foundation length can be obtained by increasing the graph value by 1 or 2 feet (0.3 or 0.6 meter). For design purposes, the foundation length determined from the graph should be increased to the next longer length that is a multiple of five (English units only).

The foregoing design procedure provides a suitable design method for determining the required caisson length as functions of soil classification, shear force and overturning moment. The soils likely to be encountered have been categorized into six values of allowable lateral soil pressures. Where existing soils information will permit identification for strength and classification, it will not be necessary to use refined design procedures involving extensive soil exploration.
Another acceptable method of design is the Broms method. The Office of Roadway Engineering makes an Excel spreadsheet available on its webpage to assist with the application and documentation of the method. Using only three basic soil parameters 1) undrained shear strength, 2) friction angle, and 3) effective unit weight, design foundation depths may be obtained for cohesive or cohesionless soils. For the many Ohio soils that do not cleanly fall into the categories of purely cohesive or cohesionless, it is recommended that the designer use each case, which have separate calculation sheets; the cohesionless calculation will represent drained condition and the cohesive calculation will represent undrained condition. The designer applies a factor of safety representative of the site and loading uncertainties, with a minimum value of 1.5 for very well-known conditions. When conditions are less well known, a factor of safety of 3-4 should be used.

Table 1197-11 presents recommended tower foundation depths calculated for structures with round tapered shafts designed in accordance with the 1975 AASHTO Standard Specifications for Structural Supports for Highway Signs, Luminaires, and Traffic Signals for a 90 miles per hour wind zone when supporting the following load:

- Six cylindrical luminaires with projected area of 3.5 square feet ($C_D = 0.5$) and weighing 75 pounds each.
- One cylindrical head from assembly with projected area of 5.3 square feet ($C_D = 1.0$) and 340 pounds top latched lowering device.
1141 PLAN PREPARATION / PRODUCTION

1141-1 General

The L&D Manual Volume 3 generally describes ODOT plan preparation and production guidelines and standards, including plan sheet format (sheet layout, text size, symbols, line weights, file-naming conventions, etc.). For reference, Figures 1314-8S through 1314-10S of the Sample Construction Plans produced by the Office of CADD and Mapping Services are sample Lighting Plan sheets. Additional information is provided in this Chapter and Chapter 1140 regarding lighting items in plans.

1141-2 Coordination with Utilities

Existing underground and overhead utility lines shall be shown in the lighting plan. Proposed utilities lines shall also be shown. Many utility companies are members of the Ohio Utility Protection Service (OUPS). Utility companies that are not members of OUPS shall be contacted individually. However, when the lighting improvement is but part of a larger project, the lighting designer should coordinate with the other designer(s) to avoid multiple requests for the same information.

The power company which will be supplying power should be contacted early in the design process to confirm that power will be available at the location(s) being considered for power services. The designer will also need to obtain from the power company any company requirements for customer services along with the costs that the power company expects to bill for their work in providing each service. The designer should later confirm with the power company the details for service at each of the points finally chosen. Written documentation signed by both the designer and the power company representative should be provided in the supporting documents accompanying the review submissions.

1141-3 Plan Composition

1141-3.1 General

For a normal ODOT project, the documentation of the work to be done will consist of the Construction and Material Specifications (C&MS), the Supplemental Specifications listed on the Title Sheet of the Plans, the Standard Construction Drawings (SCDs) listed on the Title Sheet of the Plans and the Proposal.

The highway Lighting Plan is usually a portion of a larger highway construction project. In such cases, the Lighting Plan will be a section of the plan for the overall improvement and listed as such in the index of sheets which appears on the title sheet. However, at times highway lighting will constitute the entire project. In those cases, items normally not included in the lighting plan must be added. Field offices, construction layout stakes and provisions for maintenance of traffic during construction are some of the things that may be needed.

The lighting portion of a plan usually consists of the following subdivisions which are to appear in the order listed.

1. General Notes.
2. General Summary of Lighting Items.
3. Sub Summaries.
4. Schematic Index.
5. Plan Views.
6. Special Details.
7. Circuit Diagrams, if used.
8. Tower Cross Sections, if used.
A title sheet is added as the first sheet of the plan only in those projects where the only work is the highway lighting improvement.

1141-3.2 General Notes

General Notes should be limited to explanations required to clarify details of the proposed work which are not satisfactorily covered in the Specifications, Supplemental Specifications, Standard Construction Drawings or elsewhere in the plans. General Notes are also commonly used for standard bid items which require supplemental information not otherwise shown in the plans or specifications, such as the specific luminaires that are to be installed or the method of maintaining the existing lighting. When a pay item varies from the standard definition to the point that it becomes an “as per plan” item, or an “item special” is used to cover work for which no standard item exists, a Plan Note is required to define the work and materials that are included in the price bid for that particular item. Chapter 1142 contains Plan Notes for a number of commonly encountered situations.

1141-3.3 General Summary

The lighting quantities can be placed in the project General Summary under the heading “Highway Lighting.” However, since the lighting portion of the plan is frequently prepared separately, they are often located in the lighting section of the plan with a cross reference under the heading in the project General Summary. The format of the Highway Lighting General Summary follows that of the project General Summary. From left to right columns are used as follows: columns to the left of the sheet bring forward the subtotals from each sub-summary sheet using one column per sub-summary sheet; the next group of columns sub-totals the units by funding participation split; the final group of columns contains item number, item extension number, grand total, unit of measurement, and item description information. The ODOT Item Master (available on-line from the ODOT Design Reference Resource Center web page) is a list of commonly used bid items including the item extension number, unit of measurement and description for each item listed. Blank lines should be used to separate the line entries into groups of five lines.

1141-3.4 Sub-summaries

Sub-Summary Sheets compile the pay items for each node and link of the highway lighting improvement. L&D Manual Volume 3 Sample Plan Sheets, Figure 1314-10S is for a sample highway lighting sub-summary sheet.

1141-3.5 Schematic Index

L&D Manual Volume 3 Sample Plan Sheets, Figure 1314-8S is for a sample highway schematic index sheet.

1141-3.6 Plan Sheets

See L&D Manual Volume 3 Sample Plan Sheets, Figure 1314-9S for a typical plan sheet. Plans shall be prepared using the English unit system. Plan sheets for tower lighting are usually prepared at a scale of 1:100 (1:1000). Plan sheets for other types of lighting are normally prepared at a scale of 1:50(1:500). However, lighting plans may be prepared to other scales when appropriate and agreed to by the District.

Each lighting plan sheet should include the following information:

1. Pavement and paved shoulder edges.
2. Curb lines, curb ramps, raised medians and islands and painted islands or similar channelizations.
3. The beginning and the end of the tapers used at the start of each deceleration lanes.
4. The end of each acceleration lane.

5. Bridge structures and retaining walls, including pier and abutment locations, and length of approach slabs. Include ODOT structure number when appropriate.

6. Drainage culverts and flow lines.

7. Existing and proposed overhead and underground utilities. Show width and/or boundaries of the utility right-of-way or easement and fence grounding points where overhead electrical lines are involved.

8. Type, wattage or lumen rating, and ownership of existing lighting in the project area, and planned disposition.


10. Funding participation boundaries.

11. Future lighting unit locations needed to portray the coordination between adjacent improvements.

12. A north arrow, located on the upper right corner of the sheet.

13. A legend, or reference to the plan layout sheet showing the legend. The legend shall indicate by appropriate symbol the various nodes (e.g., light poles, light towers, pull boxes, junction boxes, power services, etc.) and links (e.g., conduits with distribution cable, unitized cable in duct assemblies, etc.) to be installed.

14. The location of each light pole foundation, conduit crossover, pull box, control center, tower, etc., by centerline or baseline station and offset distance from the controlling pavement edge. Include the maintenance platform type, if any.

15.Existing and proposed rights-of-way (R/W).


17. Illuminated signs. Show an appropriate symbol, the sign installation number, the centerline station and the total wattage of the installation.

18. Combination supports. Clearly indicate the nature of the combined support (e.g., Sign & Luminaire, Signal & Luminaire) and show all applicable data for electrical service and the separate bid items necessary to provide the lighting components. Add a cross-reference to the Traffic Control Plan sheet showing the support details.

19. Begin Project and End Project, along with work limits for the mainline and for each crossroad.

20. Match lines. Avoid the use of match lines along the centerline of any illuminated roadway.

21. Station equations. Show the station equations along lines of survey, between centerline of route and baselines of roadways, crossings between routes and intersections of roadways.

22. If landscaping is part of the project, proposed trees in areas adjacent to the proposed light poles should be shown.

1141-3.7 Special Details

Special detail sheets should show only those details which are not covered in the SCDs, the C&MS or the Supplemental Specifications. In cases where modification of a standard detail is necessary, variations from the standard should be clearly identified. Clearly indicate the location(s) to which the detail applies especially if it does not apply to all locations within the project. The designer should carefully review the latest edition of the Traffic SCD HL series to determine if a particular detail has been covered before creating of a special detail drawing.

1141-3.7.1 Required Special Details for Underpass Lighting

If the lighting plan includes underpass lighting, the following should be included for each
lighted underpass: a detail view indicating the location of each luminaire; the disconnect for the underpass lighting; and the routing of all conduits comprising the service to underpass lighting from the pull box or junction box that is the point of connection of the main lighting circuit.

1141-3.8 Circuit Maps

When the lighting installation is large and circuits continue across several sheets, a map of each circuit in abbreviated detail should be included. The Control Center Data Chart (Figure 1198-11) should be included on the map of the first circuit (numbered “1” or “A”) radiating from the service point. The maps of all other circuits radiating from that service point should contain a cross reference to the sheet on which the data table for that particular service appears. If circuit maps are not being prepared for an installation, then the Control Center Data chart should be located on the plan view sheet showing the location of the service.

1141-3.9 Tower Cross Sections

To support the pole height selected for each tower, the designer will usually provide pavement elevation(s) for the roadway(s) lighted by each tower and finished grade at the base of the tower in tabular form on supplemental worksheets and no cross sections will be drawn.

In some cases, this will be illustrated by a cross section drawn from the edge of pavement out through the location of the tower, or if the tower lights multiple roadways, a cross section will be drawn from each roadway out through the tower location.

1141-3.10 Wiring and Circuit Designations

In plan preparation, it is very important to describe existing and proposed circuits correctly. Wiring for lighting circuits requires the following information in order to be completely described:

1. Number of wires;
2. Number of Conductors;
3. Nominal voltage (typically, L-N and L-L shown);
4. The phrase “with ground” as required; and
5. Wire size (gauge) as required.

Note that the Ground wire (grounding conductor) of a system is not counted as a conductor (because it does not carry load current), but it is counted as a wire. The Neutral wire is the grounded conductor.

Thus, when drafting plans, the clearest way to mark circuits is by specifying both the number of conductors and number of wires, as in the example below:

3W/2C

Some example wiring and circuit designations are shown below. The designation in parentheses is the terminology per NEC-2011 Art. 250.26, which applies to circuits that use a grounded conductor; it is also helpful in describing the circuit.

1. 2-wire, 2-conductor, 240/480V
   — L1 (240V) —
   — L2 (240V) —

2. 2-wire, 2-conductor, 480V (a single-phase, 2-wire system, common on very old ODOT lighting installations)
   — L1 (480V) —
   — N —
3. 3-wire, 2-conductor, 120V, with ground (a single-phase, 2-wire system)
   — L1 (120V) —
   — N —
   — G —

4. 3-wire, 2-conductor, 240V, with ground (a single-phase, 2-wire system)
   — L1 (240V) —
   — N —
   — G —

5. 3-wire, 2-conductor, 277V, with ground (a single-phase, 2-wire system)
   — L1 (277V) —
   — N —
   — G —

6. 3-wire, 3-conductor, 120V/240V (a single-phase, 3-wire system)
   — L1 (120V) —
   — L2 (120V) —
   — N —

7. 3-wire, 3-conductor, 240V/480V (a single-phase, 3-wire system)
   — L1 (240V) —
   — L2 (240V) —
   — N —

8. 4-wire, 3-conductor, 240V/480V, with ground (a single-phase, 3-wire system)
   — L1 (240V) —
   — L2 (240V) —
   — N —
   — G —

9. 5-wire, 4-conductor, 480Y/277, with ground (a three-phase system)
   — L1 (277V) —
   — L2 (277V) —
   — L3 (277V) —
   — N —
   — G —

10 3-wire, 2-conductor, 480V (a common circuit configuration on older systems)
    — L1 (480V) —
    — N —
    — G —

1141-4 Submissions and Project Development Reviews

1141-4.1 General

L&D Manual Volume 3, Chapter 1400 and Section 140-7 contain general information about the various submissions required and reviews conducted during the development of the plan for a project. The Scope of Service may also contain specific requirements for the project at hand. Normally, reviews of the highway lighting portion of the plan will be conducted at Stage 2 and Stage 3 of the Plan Development Process.

1141-4.2 Project Development Process Stage 2

At Stage 2, the Lighting Plan is not complete, but the essentials are in place. The location of each luminaire and support is known. The calculations supporting those locations have been made. The possible power service points have been found and those with the best fit selected.
Circuits have been laid out and preliminary checks made to determine that cable sizes will not be excessive. A rough estimate of the load at each power service point has been made to determine that the equipment will be of an acceptable size. The serving utility company has been contacted, and written confirmation obtained from the company that service will be made available at the desired location(s) and that the service will be of the concept envisioned by the lighting designer.

Two sets of full-size (22 x 34 inches) prints of the preliminary highway lighting plans should be submitted to the appropriate District as part of the entire Stage 2 submittal process. Each of the full size sets is to be accompanied by a half-size (11 x 17 inches) set of the roadway plan view sheets. The roadway plan views are not reviewed during the lighting review, but are for the lighting reviewer’s reference.

Two copies of the computations and/or computer analyses used to support the illumination design should also be included with the Stage 2 submission. A separate analysis for each of the proposed luminaire packages is required. Normally, a package will consist of luminaires from a single manufacturer. Normally, there will be three luminaire packages. The luminaires commonly used in the design of ODOT highway lighting installations may be obtained from the Office of Roadway Engineering.

Additional half-size sets of the highway Lighting Plan may be required if any of the lighting will be turned over to a local government to maintain. Normally, these half-size sets will not be accompanied by a set of the roadway plan views or by the illumination calculations.

The exact number of review sets and the composition of each review set (full or half-size, the supporting documents to accompany each set, etc.) should be verified with the District prior to making the submission.

1141-4.3 Project Development Process Stage 3

At Stage 3, the Lighting Plan is now complete. All that remains is to clean up the CADD files and print the tracings. Notes have been written; Summaries are completed; and details have been drawn. The serving utility has committed in writing to the details of each service. All utility companies, either directly or through their respective protection services, have confirmed that clearances are adequate. Comments from previous review have been resolved. Nothing has been omitted.

Two sets of full-size (22 x 34 inch) prints of the highway Lighting Plans should be submitted to the reviewing District. Each of the full-size sets is to be accompanied by a half-size (11 x 17 inch) set of the roadway plan view sheets. The roadway plan views are not reviewed during the lighting review, but are for the lighting reviewer’s reference.

Two copies of the computations and/or computer analyses used to support the design are also to be included with the Stage 3 submission. The illumination calculations may be omitted if there has been no revision since the previous submission and the previously submitted calculations were approved as adequate. If the luminaire placement calculations are omitted, this should be stated and the reason noted in the letter of submission. Support height calculations (tower height calculations) and cable sizing calculations (voltage droop or drop calculations) normally come in for review for the first time at this point. A written response to the comments and recommendation from the previous review is to be included.

Additional half-size sets of the highway Lighting Plan may be required if any of the lighting will be turned over to a local government to maintain. Normally, these half-size sets will not be accompanied by a set of the roadway plan views or by the illumination calculations.

The exact number of review sets and the composition of each review set (full or half-size, the supporting documents to accompany each set, etc.) should be verified with the District prior to making the submission.
1100 HIGHWAY LIGHTING

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1141-4.4 Review Checklists

1141-4.4.1 General

The following checklists were developed to aid ODOT design reviewers; however, they should be helpful to original designers in preparing plans for submission for approvals. Additional checklists are available in the Lighting Design Reference Packet.

All lighting plan submittals to ODOT Central Office shall include a copy of the Scope of Services.

1141-4.4.2 Stage 2 Plans

General items to check for Stage 2 plans:

1. Is the plan drawn to a scale of not less than 1:100?
2. Does the plan show the edge of the pavement, the edge of paved shoulder, the beginning and end of the taper at the start of parallel deceleration lanes, the end of the taper on acceleration lanes, raised medians and islands, painted islands, and all structures?
3. Are drainage ditches, flowlines, culverts and catch basins shown? Are pier and abutment locations shown for all interchange structures?
4. Are corporation lines shown?
5. Are existing and proposed overhead electrical and communications lines and underground utilities shown?
6. Does the submission show the IES distribution, lamp type and wattage or lumen rating, mounting height and ownership of each existing lighting unit in and adjacent to the project area?
7. Is the location for each proposed lighting unit shown?
8. Are future lighting unit locations, which must be coordinated with the proposed lighting, shown?
9. Is the proposed power service(s) shown?
10. Is the proposed circuit(s) shown?
11. Does the submission include supporting documentation showing that the lighting design criteria have been met, with regard to such things as initial intensity, uniformity ratios, mounting heights, luminaires and lamps, etc.? For complex projects at Stage 2, straight-line, simplified design tool outputs (e.g., Visual™ Roadway Tool) are acceptable.

1141-4.4.3 Stage 3 Plans

1. General items to check for Stage 3 plans:
   a. Are symbol legends uniform for the entire Lighting Plan? Do tower lighting symbols indicate which are symmetrical, which are asymmetrical, and which are long and narrow distributions?
   b. Have all guardrails and barriers been shown on the Lighting Plan sheets?
   c. Have applicable structure numbers for each bridge been shown on the Lighting Plans?
   d. Are the pertinent jurisdictional boundaries such as State, County, Township, City
or Power Company Service Area shown?
e. Has consideration been given to the need for glare shields? Where required, is their use clearly warranted?
f. Where existing or proposed overhead power transmission, power distribution, or telephone lines are located in the vicinity of light poles, light towers, or overhead signs, do the vertical and horizontal clearances from the proposed lighting installations meet the requirements of the National Electrical Safety Code and the requirements of the utility companies? Are all overhead lines shown in lighting plan?
g. Are tower pole locations located beyond clear zones established in L&D Manual Volume 1, Section 600.2? If not, has the hazard created been properly mitigated?
h. Have FAA glide path clearance requirements been met when the project is near an airport?
i. Are all service pole and control center locations accessible for maintenance purposes, particularly during wet weather and winter seasons? Where these facilities must be located at ground elevations below connecting conduit systems, have pull boxes been provided at the base to prevent any incoming water from rising into the control equipment?
j. Is circuitry clearly delineated?
k. Are pilasters, junction boxes, conduit, etc. shown on the bridge and retaining wall plans?
l. Are pilasters and conduit systems included on structures where provisions for future lighting are required?
m. Have structure grounding systems been included on all bridges requiring same?
n. Are locations of special trenching (deeper or wider than normal) clearly delineated on the plans? Are fence grounds needed?
o. Are items with other than normal project funding clearly indicated both on the plan sheets and in the summaries and are the participation splits for each item defined?
p. Has supporting documentation for the height of each light tower been provided?
q. Has supporting documentation for the depth of each tower foundations been provided?
r. Have cable sizing (voltage drop or drop) calculations been provided?
s. Has the serving power company committed in writing to provide service of the type proposed at each service point being proposed?
t. Is there a need to maintain existing lighting on the project? If so, has the “Maintain Existing Lighting” Plan Note been included.
u. Are required lighting Standard Construction Drawings listed on the title sheet of the plans with appropriate dates?
v. Have District and Local preferences been incorporated into the plan?

2. Details to check:
a. Are there any poles which need to be of special heights to compensate for the pole being mounted significantly higher or lower (e.g., on a tall retaining wall, on ground below a bridge and reaching above the bridge, etc.) than the roadway?
b. Are voltage and type of service furnished by the power supplying agency shown?
c. Has the Control Center Data Chart been shown?
d. Where fencing is to be installed around a control center, have the necessary dimensions, notes, and grounding and other details been shown, and provisions made for payment?
e. Are all conduits included in lump sum bid items clearly identified and the material specified?
f. Are sizes and locations of all cable clearly shown?
g. Are complete design output results shown, with legible point illuminance values and summary statistics tables?

3. General Notes:
   a. Are the Plan Notes listed in Chapter 1142 included, when applicable?
   b. Where reference has been made to specific products, has the “or equal approved by the Engineer” phrase has been include?
   c. Where there are median mounted poles, does the roadway plan provide the proper barrier?

4. Summaries:
   a. Are sub-summaries in accordance with the Sample Plan Sheet?
   b. Where a combination support is proposed, is the separation of bid items between the highway Lighting Plan and the signal or signing portion of the plan clear and coordinated?
   c. Have anchor bolts been separately provided for poles where the standard anchor bolts supplied with the pole will not be available (i.e., relocated poles) or will not fit the mounting condition (i.e., bridge or retaining wall) encountered?
   d. Has trenching been separated according to depth?
   e. Is conduit to be encased in concrete before closure of the trench separated from that which will not?
   f. Is each conduit to be placed in an area where the surface is not to be disturbed being installed by jacking or boring?
   g. Are items with other than normal project participation in the funding properly identified and in separate line items from those with normal project funding?
   h. For special bid items, are methods of measurement and basis of payment clear? Have all necessary notes and details been shown? Does description of the item clearly indicate that component parts not specifically mentioned, but required for satisfactory operation shall be furnished and considered paid for as part of the item?
   i. Have sub-summary sheet totals been properly carried to the General Summary?
   j. Does the item description of each line item comply with the requirements of the Item Master? Are the item number and item extension number correct for the description and unit of measurement used?
1142 PLAN NOTES

1142-1 General
This area is reserved for sample/typical Plan Notes that have been developed for highway lighting.

1142-2 625, Pull Box Cleaned
This item of work shall consist of cleaning an existing pull box by removing any existing cables not being reconnected, and debris so that new cables can be installed. Any unused openings shall be closed. Disturbed areas near the pull box shall be cleared of weeds or debris and shall be fully restored. Material removed shall become the property of the contractor and shall be properly disposed of off of the project site.

Payment will be made at the unit price bid under C&MS Item 625, “Pull Box Cleaned” for each pull box cleaned which shall be full compensation for all labor, materials and incidentals required to complete this item in a satisfactory and workmanlike manner.

1142-3 625, Conduit Cleaned and Cables Removed
This item shall consist of cleaning an existing conduit by removing existing cables, mud and debris so that new cable can be installed. Incidental to the cleaning is the installation of bushings and/or couplings on the ends of existing conduit as required. Materials removed shall become the property of the contractor for proper disposal off of the project site. Disturbed areas shall be properly restored.

Payment will be made at the unit price bid under C&MS Item 625, “Conduit Cleaned and Cables Removed” per foot of conduit cleaned which shall be full compensation for all labor, materials and incidentals required to complete this item in a satisfactory and workmanlike manner.

1142-4 625, Anchor Bolt and Concrete Repair
This item consists of restoring concrete median barriers and foundations after field repairs are made to flawed anchor bolts. Perform anchor bolt field repairs according to a written procedure provided by the anchor bolt manufacturer, and only after obtaining signature approval of the procedure by the Engineer.

1. For newly-constructed joints kept continuously damped (e.g., overnight work pauses, etc.):
   a. Workmanship: 2016 C&MS 511.09 and 511.10 should govern the joint, with the exception that a “keyway” can be provided by a suitably rough interface, which is provided chipping away the old barrier concrete from around the anchor bolts and preparing the surface.
   b. Materials: should be the same concrete item as for the original median barrier or foundation (e.g., QC1); assure that the Engineer is able to subject this repair material to all the same material tests required of the original concrete.
   c. C&MS 625.10 calls for QC Misc. or QC1 concrete for foundations.
   d. Speed of set is not usually important for barrier wall and foundation repairs, because they do not carry traffic. Consult with the Engineer if any variation in C&MS 511.14 Curing and Loading is anticipated.

2. For “old” joints (more than a few days if kept continuously damp), follow 2016 C&MS 256, noting the following:
   a. This is a procedure designed for pavement repair, usually (but not always) using bonding grout at the interface (see 256.07.A-C).
b. The repair material is not concrete in kind, but patch material per 256.07. Coarse aggregate should be added, as needed, to extend the patch material if the repair volume and gaps are large enough.

Payment for this item will be made at the bid price, for each foundation repaired, regardless of the number of anchor bolts contained in the foundation.

1142-5 Luminaire, High Mast, As Per Plan

The luminaire arrays and associated illumination test areas specified in C&MS 725.11 are hereby waived. Instead, the luminaires for high-mast lighting shall meet the following requirements:

Luminaires for high-mast lighting units with symmetric distribution shall be Holophane "HMST" with photometric distribution 36383, General Electric "HM" with photometric distribution 6312, or Cooper "HMX" with photometric distribution HMX4SDW, or equal as approved by the Engineer.

Luminaires for high-mast lighting units with asymmetric distribution shall be Holophane "HMST" with photometric distribution 46973, General Electric "HM" with photometric distribution 7349, or Cooper "HMC" with photometric distribution HMC4S3D, or equal as approved by the Engineer.

Luminaires for high-mast lighting units with long narrow distribution shall be Holophane "HMST" with photometric distribution 36801, General Electric "HM" with photometric distribution 8946, or Cooper "HMC" with photometric distribution HMC4S1DL, or equal as approved by the Engineer.

In addition, other luminaires will be considered if the designed intensity and uniformity are provided using the designed pole locations and the designed number and type of fixtures per pole.

1142-6 Luminaire, Low Mast, As Per Plan

The luminaires shall be as specified for high-mast luminaires in C&MS 725.11 except that the luminaire arrays and associated illumination test areas are hereby waived. In addition, the luminaires for low-mast lighting shall meet the following requirements:

Luminaires for low-mast lighting units with symmetric distribution shall be Holophane "HMST" with photometric distribution 36383, General Electric "HM" with photometric distribution 6312, or Cooper "HMX" with photometric distribution HMX40SXXDW, or equal as approved by the Engineer.

Luminaires for low-mast lighting units with asymmetric distribution shall be Holophane "HMST" with photometric distribution 46973, General Electric "HM" with photometric distribution 7349, or Cooper "HMC" with photometric distribution HMC4S3D, or equal as approved by the Engineer.

Luminaires for low-mast lighting units with long narrow distribution shall be Holophane "HMST" with photometric distribution 36801, General Electric "HM" with photometric distribution 8946, or Cooper "HMC" with photometric distribution HMC4S1DL, or equal as approved by the Engineer.

In addition, other luminaires will be considered if the designed intensity and uniformity are provided using the designed pole locations and the designed number and type of fixtures per pole.

1142-7 625, Luminaire, Conventional, As Per Plan

In addition to the requirements of ODOT'S Construction and Material Specifications, luminaires for conventional lighting units shall be as follows:

Luminaires for conventional lighting units with an IES II-M-SC distribution and 200 Watt high pressure sodium lamps shall be American Electric "Series 126" with photometric distribution
AE3849I (adjust lumen value for 200w HPS), Cooper “OVX” with photometric distribution
OVX25SXX2DF (adjust lumen value for 200w HPS), General Electric “M-400” with photometric
distribution 1014 (adjust lumen value for 200w HPS), or equal as approved by the Engineer.

Payment will be made at the unit bid price for each C&MS Item 625, “Luminaire, Conventional,
As Per Plan (add supplemental description)” for each luminaire which shall be full compensation
for all labor, materials and incidentals required to complete this item in a satisfactory and workmanlike manner.

1142-8 625, Luminaire, Post-top, As Per Plan

In addition to the requirements of ODOT’s Construction and Material Specifications,
luminaires for post-top lighting units used in green spaces of rest areas shall be as follows:

Luminaires shall be American Electric “Contempo Series 245/246” with photometric distribution
P5236, Cooper “USA Style King” with photometric distribution USA1S55, General Electric
“PM16/PM17” with photometric distribution 6928, or equal approved by the Engineer.

Luminaire refractors may be of glass, polycarbonate, or acrylic.

Payment will be made at the unit price bid under C&MS Item 625, “Luminaire, Post-Top, As
Per Plan (add supplemental description)” for each luminaire which shall be full compensation
for all labor, materials and incidentals required to complete this item in a satisfactory and workmanlike manner.

1142-9 625, Luminaire, Underpass, As Per Plan

In addition to the requirements of ODOT’s Construction and Material Specifications,
luminaires for underpass lighting shall be as follows:

Luminaires for underpass lighting units shall be American Electric “Sidelight series 582” with photometric distribution AE2081, Cooper “Wall Light” with photometric distribution
WPK15SXX, General Electric “Versaflood II Wallighter” with photometric distribution 8578,
Holophane “Wallpack II” Test with photometric distribution 33263, or equal as approved by the Engineer.

Luminaire for underpass lighting unit which are wall mounted shall be furnished with an
integral fuse holder and 10-ampere fuses.

Payment will be made at the unit price bid under C&MS Item 625, “Luminaire, Underpass,
AsPer Plan (add supplemental description)” for each luminaire which shall be full compensation
for all labor, materials and incidentals required to complete this item in a satisfactory and workmanlike manner.

1142-10 625, Luminaire, Installation Only, As Per Plan

This item of work shall consist of installing an existing luminaire removed from a previous
location on the project or supplied to the project site by others.

The luminaire shall be cleaned, repairs to ensure that it is in good serviceable condition made,
adjustments to the optical components to ensure that the specified distribution is being
produced made, and a new lamp installed if the light source is a lamp.

Payment will be made at the unit price bid under Item 625, “Luminaire, Installation Only, As Per
Plan” for each luminaire installed and shall be full compensation for all material, labor,
equipment and incidentals necessary to complete this item in a workmanlike manner.

1142-11 Lamps

High pressure sodium lamps shall be General Electric “Lucalox,” Osram Sylvania “Lumalux,”
Philips “Ceramalux,” or equal approved by the Engineer.

1142-12 625, Light Pole, Installation Only, As Per Plan

This item of work shall consist of installing an existing light pole removed from a previous
location on the project or supplied to the project site by others.
The light pole shall be cleaned and repairs needed for the pole to be in good serviceable condition made. The existing pole number decal shall be removed if it is in poor condition or the pole number has changed. A pole number decal shall be supplied and applied if the existing decal is removed or missing.

When required, new anchor bolts shall be furnished as part of this item.

Payment will be made at the unit price bid under Item 625, “Light Pole, Installation Only, As Per Plan” for each pole installed and shall be full compensation for all material, labor, equipment and incidentals necessary to complete this item in a workmanlike manner.

1142-13  625, Light Tower, Installation Only, As Per Plan

This item of work shall consist of installing an existing light tower removed from a previous location on the project site or supplied to the project by others. When required, additional luminaire bracket arms shall be added to the existing luminaire brackets relocated along with the necessary adjustments and additions to the luminaire wiring to enable the luminaires to be mounted symmetrically around the luminaire mounting ring. Where the tower will be installed on a new foundation, new anchor bolts shall be furnished. The tower and lowering mechanism shall be cleaned and lubricated. Any repairs and adjustments necessary to return the tower and mechanism to good operating condition shall be made. The existing light tower identification decal shall be removed, and a new decal for the new identification number furnished and installed. Payment shall be made at the unit price bid under C&MS Item 625, “Light Tower, Installation Only, As Per Plan” for each tower re-erected which shall include all labor, materials and incidentals required to complete this item in a satisfactory and workmanlike manner.

1142-14  Light Pole Anchor Bolts On Structures

When a light pole is mounted on a pilaster on a bridge parapet or on a retaining wall, the required anchor bolts may differ in length and/or shape from those required when the pole is mounted on a cast-in-place drilled shaft foundation. The cost differential for furnishing such bolts is included herein. In addition, there is no foundation construction item in which to include the setting of the anchor bolts. Thus, the setting of the anchor bolts into the pilaster is also part of this work. Payment will be made at each such pole location at the unit price bid for each C&MS Item 625, “Light Pole Anchor Bolts On Structure” and shall be full compensation for furnishing and placing the set of anchor bolts required.

1142-15  Reserved for Future Information

This Section is reserved for future information.

1142-16  Conduit Expansion and Deflection

Expansion fittings shall be OZ Type AX, Crouse Hinds Type XJG, or equal approved by the Engineer. Each expansion fitting shall provide either 4 or 8 inches total movement as specified by the plan details and shall have an external copper bonding jumper, unless specified otherwise by the plan details.

Deflection couplings shall be OZ Type DX, Crouse Hinds Type XD, or equal approved by the Engineer. Each deflection coupling shall have an external copper bonding jumper, unless specified otherwise by the plan details. Minimum deflection capability: 25°.

Expansion and deflection fittings fully or partially embedded in concrete, soil, or similar material shall be completely wrapped in a neoprene sleeve or sheet of 1/2-inch minimum thickness.
Secure neoprene wrap with tie-wraps prior to embedment of the fitting.

1142-17 **625, Power Service, As Per Plan**

In addition to the requirements of the Specifications, the following is added.

The power supplying agency for this project is:

Power Company ____________________________
Address __________________________________
Phone # ____________________________
Contact Name __________________________

The Engineer shall ensure that each power service electrical energy account is in the name of and that the billing address is to the maintaining agency noted in the plans. This shall be done not only for each new power service established by this project but also for each existing power service, since there may be a reassignment of the responsibility for an existing service as a result of the work performed by this project.

Payment will be made at the unit bid price for each C&MS Item 625, “Power Service, As Per Plan” which shall be full compensation for all labor, materials and incidentals required to complete this item in a satisfactory and workmanlike manner.

1142-18 **Special, Power Service Fence**

This item of work shall consist of installing a new chain link fence, with gate, around a power service. The fence and gate shall be installed as specified in C&MS 607 and in the plan. The fence shall be 8 feet in height, and one gate of 4 feet in width shall be included, except as specified herein unless detailed otherwise in the plan.

Where the power service is adjacent to the right-of-way fence and there is reasonable access to the power service from outside the highway right-of-way, the fence around the power service shall utilize the right-of-way fence line as a portion of the fence line of the enclosed area. The right-of-way portion of the fence shall include a second access gate.

The gate hasp of each gate shall be secured by a steel rod, with one end drilled for the maintaining agency padlock and the opposite end drilled for the power company padlock.

Payment will be made at the unit price bid under Item Special, “Power Service Fence” for each area fenced which shall be full compensation for all labor, materials and incidentals required to complete this item in a satisfactory and workmanlike manner.

1142-19 **High Voltage Test Waived**

The high voltage test shall not be performed on the circuits constructed by this project, since the test could damage the portion of the completed circuit which has been in service prior to this project.

1142-20 **Padlocks and Keys**

Padlocks furnished shall be either brass or bronze, equal to Master No. 4BKA or Wilson Bohannan 660A, and shall be keyed in accordance with C&MS 631.06. Payment shall be included in the bid for the item(s) being locked.

1142-21 **Special, Maintain Existing Lighting**

Existing roadways which are to remain open to traffic during construction of this project and which are lighted shall have the lighting maintained as described herein.

Before any work is started in the immediate vicinity of the existing lighting circuits, representatives of ODOT, the Maintaining Agency and the Contractor shall make a visual inspection of the existing roadway lighting circuits to be maintained. During this inspection, a
written record of the condition of existing lighting shall be made by ODOT’S representative. This written report shall note individual luminaires which are not in working order, individual poles which are not standing, and individual circuits which are not in working order. The completed report shall be signed by the representatives of ODOT, the Maintaining Agency and the Contractor.

If, as a result of this inspection, it is determined that the condition of the existing system is below that required for the safety of the traveling public, then the Maintaining Agency shall make the repairs necessary to return the system to an acceptable condition. Following these repairs, the system shall again be inspected and a report shall be made and signed as outlined herein.

When the existing system is in an acceptable condition, it shall be turned over to the Contractor who shall then be required to maintain the existing lighting to the condition outlined in this report with the exception of knockdowns due to traffic accidents.

Replacement of knocked downed units shall be done only when the Engineer has determined that the replacement of the knocked down unit is necessary and shall be paid separately on a unit basis.

Betterments shall be covered in items of work pertaining to the construction of permanent improvement.

When the sequence of construction activities requires, or should the Contractor desire, the removal of the existing lighting before the new lighting is operational, the Contractor shall be responsible for providing temporary lighting of this portion of the roadway.

Prior to installing such lighting, the Contractor shall prepare and submit four sets of the temporary lighting plan to the Engineer for review and approval.

This plan shall show locations of poles, lengths of bracket arms, styles of luminaires, mounting heights, wiring methods and other pertinent information. The temporary lighting shall provide an average initial intensity of 1.2 footcandles with an average to minimum uniformity not to exceed 3:1. Mounting height of temporary luminaires shall not be less than 30 feet, and the minimum overhead conductor clearance shall be 20 feet. Temporary overhead construction shall not be less than Grade "B" for strength requirements as defined by the National Electric Safety Code. Wood poles with overhead wiring may be used. However, temporary lighting shall meet Federal and State safety criteria. If breakaway poles are used to meet these criteria, then underground wiring shall be used. Reconditioned or used materials may be furnished for temporary lighting.

All materials necessary to complete the temporary lighting shall be furnished and installed by the Contractor. When no longer needed, the temporary lighting installation shall be removed and properly disposed of by the Contractor.

The Maintaining Agency will pay for electrical energy consumed by existing power services and by proposed permanent power services after acceptance of the lighting work. The Contractor will pay for electrical energy, installation, removal and maintenance of any temporary power services.

The lump sum price bid for Item Special "Maintain Existing Lighting" shall include payment for all labor, equipment, materials and incidentals necessary to maintain the existing lighting as specified herein.

The unit price bid for Item Special "Replacement of Existing Lighting Unit" shall be full payment for the replacement of an existing lighting unit which has been knocked down after the aforementioned inspection and shall include all labor, equipment, materials and incidentals necessary to provide a replacement for such unit.

1142-22 625 Lighting, Misc.: FAA Type L-864 Obstruction Lighting, LED

This item consists of installation and testing of FAA L-864-compliant obstruction lighting for marking of structures over 150 feet. Location and wiring shall be as shown in the Bridge Plans.
Each obstruction lamp shall utilize Light Emitting Diodes (LEDs). The obstruction lamp shall have a written minimum 5-year manufacturer warranty. The lamp shall be ETL verified to FAA Advisory Circular AC150/5345-43F, Type L-864 and shall be one of the following or approved equal:

1. Specialty Tower Lighting Model RB-LED
2. International Tower Lighting Model IFH-1710
3. Point Lighting Model PFB-37001

Each obstruction lamp shall have its own controller, housed in its own metal enclosure accessible by maintenance personnel standing at floor level. The controller shall operate at 120VAC, 60Hz and have its own dedicated circuit breaker in a nearby panelboard as detailed in the Bridge Plans. The controller shall produce the appropriate FAA-required flashing rate, and the obstruction lamp shall operate continuously twenty-four (24) hours per day, with no intervening photocell control. The controller shall provide at least one unused alarm status output in the form of a dry-contact or solid-state relay closure that responds to defective or inoperative obstruction lamp conditions. At least one relay with complete contacts (Normally Open, Normally Closed, and Common) shall be provided. Alarm relay contact ratings shall be at least 500 mA resistive at 120VAC/30VDC. The controller shall provide at least one visible alarm status indicator for lamp failure indication. This indicator shall be in the form of a panel-mounted red dome-type LED visible from the outside of the enclosure.

The controller enclosure shall utilize a vertically hinged, swing-open door, and be rated NEMA 3R, minimum. Enclosure shall include at least one commercial grade NEMA 5-15 receptacle to accommodate wireless communication equipment to be installed later by ODOT for alarm status monitoring. An integral shelf shall be provided for this equipment inside the enclosure, and shall provide an open, accessible space for equipment measuring at least twelve (12) inches wide, eight (8) inches deep, and six (6) inches in height.

The Contractor shall fully test the system and arrange for acceptance inspection of the Obstruction Lighting installation by ODOT District signal maintenance personnel after the system is operational. During acceptance inspection, the Contractor shall demonstrate the proper operation of all lamps and alarms. Contractor shall provide written manufacturer warranty and all operating manuals for obstruction lighting controller and lamp to ODOT District signal maintenance personnel at the time of inspection.

The Department shall measure LED FAA Type L-864 Obstruction Lighting by each individual obstruction light, complete and installed including any control devices and all wiring and conduits.

**Designer Note:** Although obstruction lighting is thought of as an incidental bridge item, this note appears in the TEM as a 625 Item because bridge lighting maintenance typically falls to District signal and lighting electricians. FAA regulations require daily visual monitoring of obstruction lighting by the operator (ODOT) if they are not equipped with automatic monitoring. Very fast notification and response times are required for repair of malfunctioning obstruction lights. The use of LED lighting significantly reduces ODOT's maintenance operations and provides much better reliability by eliminating the frequent outages and routine lamp changes associated with obstruction lights using older incandescent lamp technology. The use of cellular modems for automatic monitoring is recommended and is coordinated through the Office of Traffic Operations.
the following manufacturers or an approved equal:

1. Tideland Signal Corporation, Houston, TX
2. B&B Roadway, Russellville, AL
3. Pharos Marine Automatic Power, Houston TX

Each marine navigation lamp shall have its own controller/power supply, housed in its own metal enclosure accessible by maintenance personnel, as shown on the Bridge Plans. The controller shall operate at 120VAC, 60Hz and have its own dedicated circuit breaker in a nearby panelboard as detailed in the Bridge Plans. The marine navigation lamp shall operate continuously twenty-four (24) hours per day, with no intervening photocell control. The controller shall provide alarm status output in the form of a blue LED confirmation light visible to ODOT maintenance personnel from deck level to indicate defective or inoperative marine navigation lamp conditions.

The Contractor shall fully test the system and arrange for acceptance inspection of the Marine navigation Lighting installation by ODOT District signal maintenance personnel after the system is operational. During acceptance inspection, the Contractor shall demonstrate the proper operation of all lamps and alarms. Contractor shall provide written manufacturer warranty and all operating manuals for marine navigation lighting controller and lamp to ODOT District signal maintenance personnel at the time of inspection.

The Department shall measure Bridge-Mounted Marine Navigation Lighting by each individual marine navigation light, complete and installed including any control devices and all wiring and conduits.

**Designer Note:** Although marine navigation lighting is thought of as an incidental bridge item, this note appears in the TEM as a 625 Item because bridge lighting maintenance typically falls to District signal and lighting electricians. The use of LED lighting significantly reduces ODOT’s maintenance operations and provides much better reliability by eliminating the frequent outages and routine lamp changes associated with marine navigation lights using older incandescent lamp technology.

**1142-24 625 Decorative Post-Top Luminaire, Solid-State (LED), Lantern Style, 3000K, Black Finish.**

This item consists of supplying and installing decorative post-top LED luminaires for street and/or sidewalk illumination.

A lantern style luminaire consists of a four discrete flat sloping sides, per HL-10.11, with or without glass or polymer panels, and a rounded or pointed top and a small cupola. Provide a luminaire with a B-U-G up-lighting rating of U2 or less.

The luminaire is intended for external on/off control and shall not include a photocell socket.

Assure the luminaire has a nominal power of 65-85 watts and a nominal color temperature of 3000K.

Provide a luminaire with factory-applied black finish.

Supply one of the following luminaires, or an approved equal:

1. AEL Valient
2. Eaton UTLD
3. GE Salem

**Designer Note:** Use this text as a plan note template for streetscape and other decorative lighting applications. The goal of the note is to assist designers by listing several models of similar luminaires when no specific requirements are set forth in the project scope. Also, the note provides for a reasonable expenditure of public funds, serving as the Base Bid for which Alternate Bid Items may be included in the Plans. The note describes functional decorative LED luminaires in the most popular style category, without excessive decorative trim. The
luminaires listed in this note are similar in aesthetic and photometric properties, provide adequate horizontal illuminance (per IES RP-8) for a representative decorative lighting scenario, and meet material and workmanship requirements similar to those of ODOT SS 813. The “generic” lighting installation used to establish this note consists of luminaires on 17-foot mounting heights (16-foot pole) on each side of a two-lane (12’) roadway with on-street parallel parking, 2-foot setback from curb, a 10-foot sidewalk, major street classification, and medium pedestrian conflict classification, yielding a longitudinal pole spacing of at least 120 feet. Lighting installations with different geometry than the “generic” installation should be designed using the same luminaires, perhaps with different distributions, mounting heights and lumen outputs, as guided by the Project Scope of Services and the specific conditions of the site. The design veiling luminance ratio shall be per RP-8. Because this note only lists a few representative models, it must always include the “or approved equal” clause so that competing models that meet the specifications may be used. The poles used to support the luminaires are not specified in this note, but should be finished black per SS 916. Colored finishes other than black shall be Alternate Bid items. The designer must assure at least three luminaires are specified in the Plans, and shall provide illumination design documentation for each.

1142-25 625, Decorative Post-Top Luminaires, Solid-State (LED), Acorn Style, Refractive Glass, 3000K, Black Finish

This item consists of supplying and installing a decorative post-top LED luminaire for roadway and/or sidewalk illumination on posts of 16 feet nominal height.

HL-10.11 shows an acorn-style post-top luminaire schematically. This item consists of a base fitter, glass (not acrylic) globe and a rounded top with no decorative features such as finial, crown, band or ribs. Provide a luminaire with a B-U-G up-lighting rating of U4 or less.

Provide a luminaire compatible with the lighting branch circuit shown in the Plans. Assure the luminaire post-fitter has a hinged or captive door. Assure the luminaire can mount a photocell or wireless control that uses a NEMA standard photocell receptacle.

Provide a luminaire with 3G vibration rating. Protect each luminaire using a Surge Protective Device (SPD) conforming to ODOT Supplemental Spec 913.

Assure the luminaire has a nominal color temperature (CCT) of 3000K.

Provide a luminaire with factory-applied black finish meeting Supplemental Specification 916.

Supply one of the following luminaires, or an approved equal:

1. Holophane Granville LED 2, ________ lumens, photometric distribution: __________
2. Sternberg G73LED Hometown Series, ________ lumens, photometric distribution: __________
3. King Luminaire K445, ________ lumens, photometric distribution: __________

Designer Note: Use this text as a plan note template for streetscape and other decorative lighting applications. The goal of the note is to assist designers by listing several models of similar luminaires when no specific requirements are set forth in the project scope. Also, the note provides for a reasonable expenditure of public funds, serving as the Base Bid for which Alternate Bid Items may be included in the Plans. The note describes functional decorative LED luminaires in the most popular style category, without excessive trim. This generic luminaire item is intended for external on/off control and should not include a photocell socket or control.

Designers should note the up-lighting and CCT restrictions intended to limit light pollution. There are options available for the refractive glass luminaires to limit up-lighting.

The luminaires listed in this note are similar in aesthetic and photometric properties, provide adequate horizontal illuminance (per IES RP-8) for a representative decorative lighting scenario, and meet material and workmanship requirements similar to those of ODOT SS 813. The “generic” lighting installation used to establish this note consists of luminaires on 16-foot mounting heights, staggered, on each side of a two-lane (12’) roadway with on-street parallel parking 8 feet wide, 2-foot setback from curb, a 8-foot sidewalk, major street classification, and
medium pedestrian conflict classification, yielding a nominal longitudinal pole spacing of at least 80 feet. Lighting installations with different geometry than this “generic” installation should be designed using the same luminaires, or as guided by the Project Scope of Services and the specific conditions of the site.

Because this note only lists a few representative models, it must always include the “or approved equal” clause so that competing models that meet the specifications may be eligible. The poles used to support the luminaires are not specified in this note, but should follow HL-10.11 and be unfinished or finished black per SS 916. Colored finishes other than black shall be Alternate Bid items. The designer must specify at least three luminaires in the Plans, and shall provide illumination design documentation for each, with a specific emphasis on the Veiling Luminance Ratio.

For lighting low-speed roadways (35mph or less) it is acceptable to exceed the RP-8 maximum Veiling Luminance Ratio value of 0.3, up to a value of 0.8. Installations on roadways with posted 85th-percentile speeds exceeding 35mph shall conform fully with RP-8 veiling luminance specifications.

ODOT’s preferred post-top decorative luminaire is the Lantern Type because of its superior Veiling Luminance performance in comparison to the Acorn Type. ODOT-maintained installations shall use acorn-style luminaires with glass globes when acorn style is required. Occasionally, local jurisdictions prefer polymer globes (acrylic typically, but polycarbonate is available). If polymer globes are required, designers may change the title of the Note and specify from among the following luminaires:

1. NLS Savannah, _________________ lumens, photometric distribution:
2. Spring City Washington, _________________ lumens, photometric distribution:
3. Holophane Washington Postlite, _______________ lumens, photometric distribution:
4. Sternberg A65LED Princeton, _________________ lumens, photometric distribution:

1142-26 625, RGBW Aesthetic Lighting System

General:
This item consists of supplying, installing, testing, and providing training for an aesthetic lighting system, according to the details shown in the Plans.

Item 625 RGBW Aesthetic Lighting System is paid for by EACH instance (typically each separate structure to be lighted), and includes the following items: luminaires, controller, wiring, conduit and fittings, communication and wireless links (if required)

The luminaires for the system shall comprise arrays of four LED emitters to generate multiple colors and white light of various color temperatures and color-rendering indices (CRI).

The luminaire array is nominally composed of RGBW (Red, Green, Blue, White) emitters but may consist of emitters with different nominal colors.

Provide an aesthetic lighting system with a software or hardware limit to the white-light surface luminance of no more than 100 cd/m² in urban/suburban areas or 50 cd/m² in rural areas at any point of an illuminated surface over or directly adjacent to the roadway.

Provide an aesthetic lighting system with programmed transitions no shorter than 5 seconds between preset states whose minimum duration is 15 seconds.

Communications:
Assure the communications used for RGBW lighting control is DMX-512.

Web server access (when required) shall be secure HTTP (https) meeting all applicable ODOT network specifications for Intelligent Transportation Systems (ITS).

Luminaires:
Record the serial number and location of each luminaire installed for documentation and DMX programming.

The luminaire shall utilize either a single cable for power and control or two separate power and control cables.

Cables shall be integral to the luminaire and a minimum length of 9 feet.

Assure luminaire power/control cables are UL listed for outdoor application and sunlight resistance.

Assure the luminaire has ingress protection of IP66, minimum.

Assure the luminaire has a 3G vibration rating per NEMA C136.31.

Supply a luminaire that matches the beam angle specified in the plans to within +/- 5 degrees.

Assure the luminaire includes a surge protective device (SPD) meeting ODOT Supplemental Specification 913.

Maintain required separation of power and control circuits per NEC Article 800.

Assure the luminaire enclosures used are watertight and UL listed for wet locations.

The following luminaires are approved by ODOT for this item.

1. Philips Gen4 ColorBurst, ColorBlast, ColorReach, or ColorGraze. Philips luminaires shall include as incidental DataEnabler Pro devices, when required. Use 5-wire IMSA traffic signal cable (732.19) for power and control, with green as the equipment grounding conductor and white as neutral. Minimum acceptable IMSA wire gage is 14AWG, or larger if called for in the Plans.

2. Acuity Hydrel 8100. Use 4-wire IMSA traffic signal cable (732.19) for power, with green as the equipment grounding conductor and white as neutral and one spare. Minimum acceptable IMSA wire gage is 14ga AWG, or larger if called for in the Plans.

3. Lumenpulse brand Lumenbeam and Lumenfacade. Include all required Lumenpulse DC power control/splitter and cables. Use 4-wire IMSA traffic signal cable (732.19) for power, with green as the equipment grounding conductor and white as neutral and one spare.

Assure that in the absence of a control signal, a powered luminaire will remain in a dark state.

Central RGBW Lighting Programmable Controller:

Locate the controller in a climate-controlled building or 820 Instrumentation Enclosure as detailed in the Plans.

The Central controller shall utilize the DMX-512 protocol.

The following programmable controllers are approved by ODOT:

1. Philips iColor Player
2. Pharos LPC-1

Central RGBW Lighting Preset Controller:

If specified, provide a surface-mounted panel with DMX output that has a minimum of 6 present lighting system configurations that are enabled by pushbutton actuation.

Assure there is a separate ON/OFF actuator on the present controller panel.

Include a programming application with the controller.

The following preset controllers are approved by ODOT:

1. Pharos BPS
2. Acuity Easyl Button Station

DMX cable:
Provide Belden 9841 or approved equal.

**Wireless DMX Transceiver:**

If called for in the Plans, install wireless DMX transceivers at each wireless link as shown. Supply wireless transceiver power using a dedicated 120VAC branch circuit from the main lighting control center location, unless indicated otherwise in the plans.

**Conduit, Fittings and Enclosures:**

Install galvanized steel, aluminum, or stainless steel rigid metallic conduit and fittings as shown in the Plans. If conduit material for this item is not specified elsewhere, then provide galvanized steel rigid metallic conduit and fittings. Install vent drains in all electrical enclosures and boxes. Install vent drains in all conduit runs exceeding 50 feet, at intervals not exceeding 50 feet between conduit system vent drains. Install vent drains in a manner that maintains the NEMA ingress rating of the enclosure. All conduits and fittings shall be UL listed for Wet Locations, constructed and installed in a manner to be watertight. Make all conduit enclosure entries using watertight hubs; do not use threaded conduit ends and locknuts. Make all wire and cable enclosure entries using watertight compression fittings. Make wire connections (e.g., wire nuts) in boxes waterproof by wrapping with 3M Number 23 self-fusing rubber tape followed by a layer of 3M Super 88 heavy-duty vinyl electrical tape, or use approved equal tapes.

Install power wiring inside ¾-inch 725.04 galvanized conduit, unless indicated otherwise in the Plans. Install all DMX control cables inside ¼-inch 725.04 galvanized conduit, unless indicated otherwise in the Plans. Support conduit at intervals of ten feet or less per NEC Article 344.

Coatings for conduits, enclosures and fittings, if required, shall meet the requirements of ODOT Supplemental Specification 916.

Provide enclosures conforming to ODOT Supplemental Specification 820.

**Field Mock-Up:**

Prior to purchasing luminaires and controls, the Contractor shall coordinate with the Engineer, the equipment vendor or manufacturer, and the project owner to conduct a test using a small number of temporary luminaires. If a structure to be illuminated is not accessible for the mock-up, a substitute location may be used if approved by the Engineer. The purpose of this test is to demonstrate to the Engineer and to the lighting system operating agency that the system proposed in the Plans meets the required engineering specifications and aesthetic qualities.

**Testing:**

1. Maximum Luminance Test: Using a photometer measuring in units of cd/m², demonstrate to the Engineer during night testing that the programmed, operational lighting system meets the maximum surface luminance criteria stated elsewhere in this Note. Set the system to its maximum output programmable configuration and measure the surface luminance using a spot or imaging photometer.
2. **Burn-In Test:**
   Following the Maximum Luminance Test, operate the system for at least fourteen days without any maintenance intervention. Demonstrate to the engineer during the night test a typical aesthetic display program. If the system is designed to provide dynamic display, then use a dynamic display program during the test period. During this interval the system must not experience any operational or equipment failures, including luminaires, control system, or programming/software. Any failures require a re-start of the testing interval.

For all aesthetic lighting installations on the Expanded National Highway System, notify the ODOT District and the administrators of the following ODOT offices at least four weeks in advance of the proposed test start and finish dates: the Office of Roadway Engineering, the Office of Structural Engineering, and the Office of Traffic Operations. A representative from at least one of these ODOT offices must be present to approve each test.

**Training:**

The Contractor shall arrange a minimum one-day (4-7 contact hours) training session on the operation of the system. Complex systems may require more than one day.

**Designer Notes:** This draft plan note serves as a template for aesthetic lighting systems used for spot, wash (luminaires pointed down), or flood (luminaires pointed up) lighting of structures and other roadside features within and near the ODOT right-of-way. Local ordinances may exist that affect design along non-ODOT right-of-way; the designer shall comply with all such ordinances.

The RGBW lighting system consists of LED luminaires using (nominally) red, green, and blue emitters that produce many different colors, including white. This same note shall be used for single-color LED luminaires with slight modification.

Use an offline preset controller by default. Programmable central control systems, when necessary, shall be deployed as follows on ODOT-operated facilities:

1. Philips iPlayer: Used for ODOT installations comprising 128 or fewer luminaires, which require four DMX addresses each. Standalone, non-networked control requiring on-site programming using a laptop computer (not included).
2. Pharos LPC: Used for ODOT installations requiring network access.

Submit lighting designs per TEM 1141-1. Use Visual™ or AGi32 design software. Model surface reflectance using maximum foreseeable values and produce plan and elevation views as necessary to show all design luminance values at 100% for at least three representative colors and for white.

Design luminance levels exceeding the limits given below must be approved by ODOT’s Offices of Roadway Engineering, Structural Engineering, and Traffic Operations.

Aesthetic Lighting Systems are sometimes placed close to the roadway, in view of drivers, so a critical design goal is to achieve the limiting luminance criteria with the luminaires set to 100% output, thus limiting the possible luminance under controller or programming error conditions. The designer is referred to CIE 150:2003 *Guide On The Limitation Of The Effects Of Obtrusive Light From Outdoor Lighting Installations*, for general design principles. However, design values shall be those given by this Plan Note or other ODOT specifications. Outdoor Advertising signs (message centers) outside of the right-of-way are not specifically addressed in this guidance for Aesthetic Lighting Systems.

Each system shall be characterized by its Environmental Lighting Zone as either Urban/Suburban or Rural, per Table 2.1 in CIE 150:2003.
### Urban/Suburban Lighting Environment

<table>
<thead>
<tr>
<th>Feature Description</th>
<th>Average Luminance (cd/m²)</th>
<th>Maximum Luminance (cd/m²)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bridge parapets, piers, arches, spandrels and other structure elevation features over or near roadways</td>
<td>30</td>
<td>100</td>
</tr>
<tr>
<td>Bridge abutment slopes</td>
<td>40</td>
<td>160</td>
</tr>
<tr>
<td>Noise walls or other walls at least 50 feet from the traveled way</td>
<td>20</td>
<td>200</td>
</tr>
<tr>
<td>Externally-illuminated signs/plaques, statues, sculptures, trees, poles and other landscape items located at least 50 feet from the traveled way</td>
<td>50</td>
<td>150</td>
</tr>
</tbody>
</table>

### Rural Lighting Environment

<table>
<thead>
<tr>
<th>Feature Description</th>
<th>Average Luminance (cd/m²)</th>
<th>Maximum Luminance (cd/m²)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bridge parapets, piers, arches, spandrels and other structure elevation features over or near roadways</td>
<td>15</td>
<td>50</td>
</tr>
<tr>
<td>Bridge abutment slopes</td>
<td>20</td>
<td>80</td>
</tr>
<tr>
<td>Noise walls or other walls at least 50 feet from the traveled way</td>
<td>10</td>
<td>100</td>
</tr>
<tr>
<td>Externally-illuminated signs/plaques, statues, sculptures, trees, poles and other landscape items located at least 50 feet from the traveled way</td>
<td>25</td>
<td>75</td>
</tr>
</tbody>
</table>

Tests show the albedo (broad visible-band light reflectance) of ODOT concrete mixes is around 0.35.

ODOT requires designers to use a fully diffuse (Lambertian) reflectance value (albedo) of no less than $\rho = 0.4$ for new vertical structural concrete surfaces for converting illuminance, $E$ (lux) to luminance, $L$ (cd/m²) using the following formula:

$$L = \frac{E \rho}{\pi} \quad \text{(see RP-8-00 Annex A)}.$$  

Note that 10.76 lux = 1 foot-candle.

Coated concrete surfaces or non-standard mixes may require the use of quasi-Lambertian or quasi-specular reflectance values during illumination design, though these may not be supported by typical lighting design software (e.g., Visual 3D).

Illumination design for aesthetic lighting may be done using Visual, AGi32, or equivalent software.

The Acuity™ Visual Floodlight Tool and Visual Wallwash Tool are also useful for initial (and sometimes final) design and ease of documentation.
The Acuity™ Visual Floodlight Tool and Visual Wallwash Tool will be used to document the design for review by ODOT; representative surfaces shall be documented separately using these online tools and results submitted to the ODOT Office of Roadway Engineering.

Designers should note that aesthetic luminaires aimed horizontally and parallel to bridge parapets and other surfaces often trespass directly into the view of drivers along the adjacent roadway and shall be designed to eliminate all such glare sources by baffles or similar means.

Horizontal surface illuminance onto streams, lakes, wetlands, wildlife crossings and other natural waters shall be limited to 0.1 fc (1.1 lux) unless specified otherwise.

Do not specify PVC or other non-metallic conduits. LFMC (Liquid-tight Flexible Metallic Conduit) may be specified as required for short flexible connections to the luminaires.

Locate the control enclosure(s) in a building or other sheltered location (e.g., under a bridge in a shaded area). See ODOT SS 820 Instrumentation Enclosure for additional enclosure requirements.

Do not use electrical and electronic control components (e.g., circuit breakers, hubs) not suitable for long-term installation in an outdoor, roadside environment.

All circuit breakers shall be 100% rated to accommodate continuous all-night operation of the lighting system.

Limit DMX cable runs to 800 feet between nodes. Control (DMX) and power conductors must utilize separate conduits per NEC Article 800.

Designers should perform voltage drop calculations to determine the required power conductor size and submit the calculations to the Office of Roadway Engineering per TEM Part 11.

Item 625 Power Service is not included as part of this item. Utilization voltage for RGBW luminaires should be 240VAC line-to-neutral, maximum, and luminaire drivers typically should be 120VAC-277 VAC auto-ranging.

Item 625 RGBW Aesthetic Lighting System is paid for by EACH instance (typically each separate structure to be lighted), and includes the following items: luminaires, controller, wiring, conduit and fittings, communication and wireless links (if required).

**1142-27 Decorative Teardrop Luminaire, Solid-State (LED), Refractive Glass, 3000K, Black Finish**

This item consists of supplying and installing a decorative Teardrop-Style LED luminaire for roadway illumination.

HL-10.11 shows an Teardrop-Style LED luminaire schematically.

This item consists of a base fitter, glass (not acrylic) globe and a basic housing with no decorative features such as finial, crown, band or ribs. Provide a luminaire with a B-U-G up-lighting rating of U4 or less.

Provide a luminaire compatible with the lighting branch circuit shown in the Plans.

Assure the luminaire can mount a photocell or wireless control that uses a NEMA standard photocell receptacle.

Provide a luminaire with 3G vibration rating.
Protect each luminaire using a Surge Protective Device (SPD) conforming to ODOT Supplemental Spec 913.

Assure the luminaire has a nominal color temperature (CCT) of 3000K.

Provide a luminaire with factory-applied black finish meeting Supplemental Specification 916.

The luminaire shall be one of the following, or an approved equal.
1. Holophane Catalog #PH150HP48N2Q120396-PS
2. King #K84- EGD-III-100HPS48V-KPL30-GN,
3. Lumec #100HPS, RN30, THBGL-480-GN8TXLMS16340

Designer Note: Use this text as a plan note template for streetscape and other decorative lighting applications. The goal of the note is to assist designers by listing several models of similar luminaires when no specific requirements are set forth in the project scope. Also, the note provides for a reasonable expenditure of public funds, serving as the Base Bid for which Alternate Bid Items may be included in the Plans. The note describes functional decorative LED luminaires in the most popular style category, without excessive trim. This generic luminaire item is intended for external on/off control and should not include a photocell socket or control.

Designers should note the up-lighting and CCT restrictions intended to limit light pollution. There are options available for the refractive glass luminaires to limit up-lighting.

The luminaires listed in this note are similar in aesthetic and photometric properties, provide adequate horizontal illuminance (per IES RP-8) for a representative decorative lighting scenario, and meet material and workmanship requirements similar to those of ODOT SS 813. Because this note only lists a few representative models, it must always include the “or approved equal” clause so that competing models that meet the specifications may be eligible. The poles used to support the luminaires are not specified in this note but should follow HL-10.11 and be unfinished or finished black per SS 916. Colored finishes other than black shall be Alternate Bid items. The designer must specify at least three luminaires in the Plans and shall provide illumination design documentation for each luminaire specified, with a specific emphasis on the Veiling Luminance Ratio. For lighting low-speed roadways (35mph or less) it is acceptable to exceed the RP-8 maximum Veiling Luminance Ratio value of 0.3, up to a value of 0.8. Installations on roadways with posted or 85th-percentile speeds exceeding 35mph shall conform fully with RP-8 veiling luminance specifications.

1143 SPECIFICATIONS

ODOT specifications for the furnishing and installation of highway lighting equipment are contained in C&MS 625 and C&MS 725. There are also ODOT Supplemental Specifications related to highway lighting. These are not listed here, so designers and others should frequently check the ODOT web page for updates, which typically occur twice per year.
1150 CONSTRUCTION

1150-1 Introduction

1150-1.1 General

The following information does not alter or supersede the contract documents. It is provided as a guide for the ODOT personnel assigned to a project to help them with their work.

Electrical construction work must adhere to the contract documents which commonly include proposal notes, project plans, standard drawings, and the Construction and Material Specifications. In addition there may be building or electrical codes or change orders that must be followed.

1150-1.2 Contractor Prequalification

Only contractors prequalified by the ODOT Office of Contracts for Work Type 43 Highway Lighting shall be allowed to do the highway lighting items of work on the project.

1150-1.3 Respect for Contractor

Contractors are prequalified for specialized work types. They bring expertise to the project and an independent perspective from the project management team. As the contractor reviews plans and specifications, he wants to ensure that he can install material that will ultimately operate as the designer intended. The contractor relies on the engineer to guide the project, to approve materials and work, and to ensure that he will be paid for work completed. It is important to remember that even when the roles of the project team and the contractor conflict successful completion of the project relies on all those involved and the maintenance of good working relationships.

1150-1.4 Protection of Utility Lines

The contractor is to notify all utilities before construction work begins. Names and addresses of these utilities are given in the project plans. It is also the contractor’s responsibility to contact the Ohio Utility Protection Services (1-800-362-2764) to have utility locations marked in all areas where digging is involved.

1150-1.5 Plan Discrepancy, Design Ambiguity, Consultation with Designer

When there is a question regarding the intent of the plan, the engineer should:

1. Define the discrepancy or ambiguity.
2. Determine if more than the highway lighting is affected.
3. Identify the standard drawings and specifications pertinent to the situation.
4. Determine potential solutions.
5. If the issue involves the location of the luminaires or light poles, the mounting height of the luminaires above the pavement, the luminaire to be used or the lamp to be used; the engineer should consult ODOT’s design office and the designer to ensure that the performance goals for the lighting system will still be met by the solution under consideration.
6. Consider the maintenance of the installation if the solution is implemented. Will parts not normally stocked by the maintaining agency be required, or will tools and equipment not normally at the disposal of the maintenance crews be required, or will special training of the workers be required?
7. Evaluate potential solutions for safety. Consider measures needed to keep errant vehicles from striking the item, the danger to those who must maintain the installation, the danger to traffic from the maintenance activities.
8. Determine if applicable codes and regulations will be met. Commonly involved will be the
1150-2 Materials

1150-2.1 General

Highway lighting items are found in Section 625 of the ODOT Construction and Material Specifications (C&MS) with detailed descriptions of materials in Chapter 725 (C&MS).

In general, all material furnished shall be new and of first quality (unless otherwise noted in the plans) and shall be identified either by a permanently attached name plate or by an indelible marking.

Before installation, all material shall be checked to determine that it is indeed the material that has been specified, that the appropriate material process has been completed and that all paperwork is in hand.

Four procedures are commonly used to ensure that the correct materials are installed.

1. Qualified Product List (QPL)
2. ODOT Plant Sampling and Testing Plan (TE 24 Certification)
3. Certified Drawings or Certified Catalog Cuts
4. Project Inspection of Material

1150-2.2 Qualified Products List

Lighting material which may be on a Qualified Product List:

1. Pull Box
2. Junction Box
3. Conduit
4. Wire and Cable
5. Ground Rod
6. Photocell

The Office of Materials Management maintains the Qualified Product Lists. The engineer can verify that the material is on a Qualified Product List (QPL) through ODOT’s Construction Management System (C&MS). After verifying that the material being supplied is that specified by the contract and on such a list, the project may accept the material.

1150-2.3 TE-24 Material Certification

Lighting material for which TE 24 Certification may be obtained:

1. Pull Box
2. Junction Box
3. Anchor Bolt

The ODOT Plant Sampling and Testing Plan (TE-24 system) is administered by the Office of Materials Management. This system was designed to allow certain material to be sampled, tested, approved and stocked for future use on ODOT projects. The material is inspected at the manufacturing or distribution site. Each approved lot of material is assigned a certification number and documented on Form TE-24. Material from the approved lot may then be transferred directly to an ODOT project or it can be transferred to other warehouses, such as a contractor’s storage facility, then transferred to a project at a later date.

1150-2.4 Certified Drawings

Lighting material requiring certified drawings (shop drawing or catalog cuts):

1. Luminaires
2. Luminaire Supports (Towers, Lowering Devices, Poles, Bracket Arms)
3. Power Service Equipment
4. Portable Power Units
5. Temporary Lighting Systems

The contractor shall submit two copies of the certified drawings prior to the installation of the material. The submittal ensures that the State has a good record of the material installed in case there are any questions about the material meeting criteria, or should additional or replacement units be required.

Each submittal shall identify the project and the bid reference number under which the item is being provided. Certified drawings shall be clearly marked by circling or underlining to indicate the exact item and options being supplied. If a given item is to be supplied under multiple bid item reference numbers, separate and complete documentation packages shall be submitted for each bid item reference number. If multiple items are to be supplied under a single bid reference number, all the items to be supplied under said reference number shall be submitted as a package. The contractor’s cover letter for each package is to certify in writing that each manufactured item in the package conforms to all contract requirements for that item.

The submittal of certified drawings does not relieve the contractor from furnishing additional information concerning the material as deemed necessary by the State.

1150-2.5 Project Inspection of Material

The following materials are normally manufactured to standards that meet ODOT criteria and therefore do not have a QPL, do not normally have a TE-24 and certified drawings are not normally required:

1. Exothermic Welds
2. Insulating Varnish
3. Split Bolt Connector
4. Expansion Fittings
5. Connector Kits
6. Splice Kits
7. Copper Crimps and Compression Connectors
8. Light Pole Decals
9. Circuit Identification Tags
10. Cable Grips
11. Wood Service Poles
12. Fuses for Control Center and Connector Kits
13. Photoelectric Cell and Bracket
14. Secondary Lightning Arrestor
15. Guy Anchors and Anchor Rods
16. Weather Heads
17. Watertight Hubs
18. Remote Ballast Enclosures and Mounting Brackets

Project inspection of material is used to verify that the material at hand is that listed on a QPL, or described on a TE-24, or for which certified drawings have been received, and that the material complies with the requirements of the contract documents. For material not on a QPL which does not have a TE-24, and for which certified drawings are not required, the project inspection of material is limited to comparing the material at hand with the requirements of the contract documents.

1150-3 Luminaires

1150-3.1 General

A luminaire consists of a housing containing the reflector, refractor, lamp socket and lamp. Unless specified otherwise, the housing will also contain the ballast components (core and coil, capacitor, starter) required for the lamp being used. The housing may also have optional components such as fuses or a photocell when such has been specified. The housing is fitted with the necessary clamps or other provisions for attaching the luminaire to its support and terminal block for the incoming power.

Verify that the luminaire installed at each location is one of the luminaires listed in the plan for
that location. Verify that the distribution, lamp type and lamp wattage are as specified in the plans. Instructions packed with the luminaire will explain the distributions that the luminaire is capable of producing and how to set any adjustments in the luminaire to provide each distribution. Verify that ballast is compatible with the circuit voltage and lamp.

1150-3.2 Conventional Luminaire

The conventional luminaire used by ODOT is also known in the trade as an “Ovate” or “Cobra Head” fixture. It may be equipped with a flat or a dropped style refractor as specified.

Verify that the luminaire is properly leveled according to the instructions packed with the luminaire.

1150-3.3 Side-Mount Roadway Luminaire

This luminaire reminds one of a floodlight.

Verify that the “tilt” has been set as specified in the plan according to instructions packed with the luminaire. Verify that the luminaire is oriented “normal” to the line of survey for the roadway being lighted unless the plans stipulate otherwise.

1150-3.4 High-Mast Luminaire

These luminaires are mounted on tall structures equipped with devices to bring the luminaires to ground level for servicing.

Verify that the luminaire is not “twisted” with regard to its bracket arm. There are three distributions commonly used. If the luminaire has a rotatable refractor, verify that it has been aligned properly.

1150-3.5 Low-Mast Luminaire

Low-mast luminaires are the same luminaire as a high-mast luminaire but installed as a fixed unit on a pole of more traditional height.

Verify that the luminaire is not “twisted” with regard to its bracket arm. There are three distributions commonly used. If the luminaire has a rotatable refractor, verify that it has been aligned properly.

1150-3.6 Underpass Luminaire

Underpass luminaires are used to light roadways beneath bridge decks. Commonly they are wall mounted on a pier cap or abutment. Sometimes they may be ceiling mounted on the underside of the deck or to a panel attached to the deck supporting beams or pendant mounted on suspension pipes attached to the structure. Occasionally, they will be post-top mounted on short poles.

Verify that the luminaire has been attached to the structure at the location and in the manner specified.

1150-4 Lamps

Verify that the lamp is one of the brands listed in the plan. Verify that the lamp type and wattage is compatible with the luminaire and its ballast. Unless specified otherwise for a particular installation, the lamps are to have clear envelopes. Do not substitute lamps with “frosted” envelopes. Verify that the installation date has been properly marked on the base of the lamp. Instructions packaged with the lamp explain how to use the dating provision built into the base.
1150-5 Supports

1150-5.1 General
The inspection of the supports (poles, arms, towers, lowering devices, brackets, etc.) consists
of two phases: inspection of the components and inspection of the completed assembly. While
these may be done together, it is better if the components are inspected upon arrival at the
project since there is then more time to obtain replacements or correct faults.

1150-5.2 Inspection of Support Components
Three areas are examined in this phase: welding, galvanizing and compliance with certified
drawings.

1150-5.2.1 Inspection of Welds
Examine each weld to verify the following:
1. Each of the welds called for by the certified drawings is present and there is no weld
   present that is not shown on said drawings.
2. There is no misalignment of the parent material being joined by the weld.
3. There has been no warping of the parent material by the weld.
4. Each weld is of the type, size and continuity shown on the certified drawings.
5. Each weld is of full cross section without excessive concavity or convexity.
6. There is no over filling or cratering at either the beginning or the end of the weld.
7. There is no undercutting (a shallow groove melted into the base metal adjacent to a
   weld and left unfilled by weld metal) along any weld.
8. There is no porosity (pitting or pinholes) in any weld.
9. There is no crack or discontinuity in either the base metal or weld material along any
   weld.

1150-5.2.2 Inspection of Galvanizing
Examine the galvanizing to verify the following:
1. There are no spots where the galvanizing is missing or loose and can be flaked off with
   a penknife.
2. There is no ash that has been picked up from the top of the bath, which usually appears
   as coarse lumps.
3. There are no pimples from entrapped bath scum particles.
4. There are no blisters from hydrogen gas absorbed during pickling being released and
   rupturing the surface of the galvanizing.
5. There are no flux inclusions from flux picked up from the top of the bath during dipping
   and burned on during immersion.
6. There are no lumps or runs of excess zinc from delayed run off of molten metal trapped
   near surface discontinuities such as joints, seams or holes as the part was lifted from
   the bath.
7. There are no rust stains from impurities from the pickling process weeping at seams
   and folds.
8. There is no general overall roughness from over pickling or of excess zinc bath
   temperature and/or immersion time.
9. There are no patches of dull gray coating from slow cooling of the heavier cross
   sections of the part after immersion.
10. The galvanizing has a uniform appearance.

Excessive galvanizing faults and gross imperfections or overall poor workmanship may be
cause for rejection of the support. Minor scratches in galvanized surfaces may be
accepted.
1150-5.2.3 Compliance with Shop Drawings

Supports are frequently shipped to the job site and stored prior to assembly and erection as components which give opportunity for the components to get mixed up, leading to improper assemblies since the basic design often does not prevent errors. Therefore, prior to beginning the assembly of a given support, it is necessary to check the major dimensions of the various components against the certified drawing for the support to verify that this has not occurred.

On poles, verify the length, base diameter, top diameter and wall thickness of each pole or section of the pole for poles shipped in multiple sections that are field assembled. Verify the length, width and thickness of the base plate along with the bolt circle diameter, bolt hole size and number of anchor bolt holes provided.

On bracket arms for conventional supports, verify the arm length and arm rise.

On lowering devices, verify the diameter of the luminaire mounting ring and number of luminaire arms on the ring. Also, verify the length of the power cord along with the wire size and number of conductors in the cord. Verify the diameter and length of each piece of hoisting cable.

1150-5.3 Assembly of Supports

Support components stored in the field should be kept off the ground to prevent finish blemishes where the components lay in contact with a damp surface, earth or water. Support components and assembled supports should be loaded, transported, unloaded, stored and erected in a manner avoiding damage to the factory applied surface finishes.

On multi-piece poles, verify that the sections to be assembled are the correct pieces for the pole at hand. Before tightening each telescopic joint between the sections, verify that the sections are properly oriented and that the male section has been marked to indicate when full insertion has been achieved. Verify that the process used for tightening the joint between sections is approved by the pole manufacturer and that the pole is not bent during the tightening process.

On each steel light pole used with an aluminum transformer base, verify that both the bottom of the pole base plate and the top of the transformer base were given a coat of zinc rich paint prior to assembly.

On each light pole, verify that the cable grip in the light pole is properly installed as shown in Traffic SCD HL-10.12 to prevent damage to the pole and bracket cable.

On each light tower, verify that the luminaire ring has the correct number of mounting arms and that each arm is attached such that when the tower is erected the arms will be in the positions relative to the roadway as shown on Traffic SCD HL-10.31. If the lowering device is equipped with top latches, verify that when the luminaire mounting ring is fully raised and latched, the latch indicator on each latch will be in the “extended” or “visible” position. Verify that all moving parts on the head frame assembly and hoist mechanism have been lubricated in accordance with the manufacturer’s instructions.

Verify that all parts are in place and that all fasteners have been properly installed according to the manufacturer’s instructions.

Verify that each handhole door or cover closes with no excessive gaps.

Verify that a light amount of anti-seize or grease lubricant has been worked into the threads of each fastener holding each removable cover in place.

1150-5.4 Erection of Supports

Prior to erection, verify that nuts can be easily turned by hand onto the threads of each anchor bolt.

When leveling nuts are to be used, verify that the leveling nuts are level before beginning the lift to set the support.
Each support should be lifted and set by crane with the hoist line attached at a point as far above the center of gravity of the support as possible, with a tethering cable from the lifting point to the base of the pole. The lifting point on poles made up of sections slip fitted together should be above the uppermost joint. Hoisting should be smooth and continuous without abrupt jerks. Light tension should be maintained in the hoist lines until an anchor nut has been threaded onto each anchor bolt far enough that the bolt is projecting though the nut by a full thread.

Verify that each support with a transformer base has been plumbed using leveling shims approved by the base manufacturer, installed between the base and the foundation according to the base manufacturer’s instructions and limitations, and that the anchor nut on each anchor bolt has been properly tightened.

Verify that each support with an anchor base installed directly on a foundation without leveling nuts has been plumbed using leveling shims approved by the pole manufacturer installed between the base and the foundation according to the pole manufacturer’s instructions and limitations, and that the anchor nut on each anchor bolt has been properly tightened.

Verify that each support with leveling nuts is plumbed by adjusting the leveling nuts, and that both the anchor nut and the leveling nut on each anchor bolt have been properly tightened.

Verify that a light tower has been plumbed early in the morning when there is minimum heat effect from the sun.

Verify that each support has been plumbed when there is no appreciable wind.

Verify that the space between the top of the foundation and the base of the support has NOT been grouted.

When a high-mast support (light tower) is equipped with a lowering device that has top latches, verify that the ring engages all latches simultaneously. This is often referred to as “leveling” the ring. It should be done following the manufacturer’s directions. Generally, the procedure is to place a block on each hoisting cable that is attached to the ring a few inches above the ring in such a manner that the block will slide along the cable when the block contacts the portion of the mechanism at the top of the tower. The ring is then raised until all blocks have made contact, but not fully raised. The ring is then lowered and the distance between each block and the ring measured. Hoisting cables are then adjusted to make the measurements equal. The process is repeated until no further adjustments are required. The blocks are removed and the lowering device operated several times through its full cycle watching all latches for proper operation.

Verify that support identification decals have the proper legend and that the decals are located approximately 7 feet above the base of the pole facing oncoming traffic.

1150-6 Foundations

1150-6.1 General
Foundation inspection normally consists of three parts: location, excavation and concrete placement.

1150-6.2 Foundation Location
After the location of each foundation has been staked, verify that the location is that specified in the plan and that Ohio Utility Protection Service and all utilities in the area have been allowed at least 48 hours to mark their utility locations relative to the proposed foundation. Then verify that the location appears logical. Be alert for the following:

1. Installing the lighting item at the staked location will require removal of vegetation that shields adjacent property owners from the highway.
2. Installing the lighting item at the staked location will locate the item at the top of the back slope, in a cut cross section or at the bottom of the fill in a filled cross section where guardrail is to be used to keep errant vehicles from going down the slope.
3. Installing the lighting item at the staked location will place the item under an overhead utility
line or over an underground utility line.

4. Installing the lighting item at the staked location will require a graded access drive for the construction that has not been addressed in the plan.

The designer should be consulted prior to relocating any support more than 10 feet or if two or more adjacent supports need to be relocated.

1150-6.3 Excavation

Foundations are to be placed only in undisturbed soil or compacted embankment.

If a minor cave-in should occur, the contractor may, with the approval of the engineer, continue excavating using sleeving or casing. When bedrock is encountered, the engineer may reduce the specified foundation depth.

If construction crews must leave the job site with a hole unfilled, it shall be covered and marked with cones, barrels or warning tape.

1150-6.4 Placement of Concrete

Verify that the top of the foundation will be at the proper elevation.

Tops of foundations shall be finished smooth and level to enable proper plumbing of the light pole.

Verify that the anchor bolts are of the correct size and number, and that each bolt is securely held in the correct position. The use of an anchor bolt setting template is encouraged. Verify that each anchor bolt will project the proper distance from the foundation.

Verify that conduit ells are present and that each ell is of the correct size and material, and that each is properly oriented.

Verify that all reinforcing bars are present and that each is of the correct size and shape.

Verify that all items to be cast into the foundation, along with any forming aids, are secured in such a manner that they will not move out of position during the placement of concrete.

Verify that water encountered in the foundation excavation is pumped out before concrete placement. If this is not feasible, verify that the concrete is placed by the tremi-tube method.

Verify that the concrete is of the proper design, has been properly mixed, has the correct slump, and is properly handled during placement. Verify that the concrete is vibrated to eliminate voids.

Verify that the top of the foundation is properly finished and that the concrete is properly cured.

1150-7 Pull Boxes (Manholes)

Verify that each pull box is of the size and material specified.

Verify that each pull box is at the planned location unless the planned location puts the box in a low spot with respect to the surrounding surface. In such cases, notify the engineer so that the engineer, in consultation with the designer if necessary, may attempt to move the box to a location where it will be less likely to hold water.

Verify that a light amount of anti-seize or grease lubricant has been work into the threads of each fastener holding the cover in place.

1150-8 Junction Boxes (Handholes)

Verify that each junction box is of the correct size and material, and securely fastened in the correct location. Verify that a light amount of anti-seize or grease lubricant has been work into the threads of each fastener holding the cover in place.
1150-9 Conduit
Verify that each conduit run is of the correct size and material.
Verify that each cut end on each piece of conduit is reamed to remove rough edges.
Verify that all field cut threads on galvanized conduit have been coated with zinc-rich paint.
Verify that each expansion or deflection fitting has a bonding strap for ground continuity when used with metal conduit.
Verify that each conduit run has been properly fastened in place.
Verify that the contractor shall check each run of conduit by rodding (pushing a mandrel through the empty conduit) or pulling a cleaning puck through the conduit.
Verify that each run of new conduit with cables contains a flat woven polyester pulling tape, rated for 600 pound minimum, in the conduit.
Verify that each run of conduit being left empty for future use contains an HDPE insulated copper tracer wire, 12 AWG minimum, in the conduit.
Verify that each end of each conduit run is terminated either in a box connector that contains an integral bushing or with a separate bushing to protect cable pulled into the conduit.

1150-10 Trench
Verify that the trench did not deviate more than 6 inches from the line designate unless such deviation has been approved by the engineer.
Verify that the sidewalls and bottom of the trench do not have any protruding sharp rocks.
When duct cable is installed in the trench, verify that the backfill material within 2 inches of the duct cable does not contain pieces larger than one-half inch.
Verify that the backfill is placed in compacted layers not to exceeding 4 inches in thickness.
When caution tape is specified, verify that the tape is installed 6 to 8 inches below grade.

1150-11 Power Service
Power service includes all equipment from the connection point to the utility company to the beginning point of the individual lighting circuits.
Verify that the power service location will be readily accessible both to maintenance personnel and to utility company personnel. There should be a safe parking area for service vehicles since the site will be visited regularly. The location should not be prone to standing or flowing water during rain events or to drifting snow. If the location appears unreasonable, involve the designer and the utility company as soon as possible, since moving a power service often means redesigning the lighting circuits.
Verify that the contractor has been in touch with the utility company and become aware of any utility company requirements which may differ from the requirements of the Contract Documents.
Verify that the photocell is facing the north sky, unless otherwise stipulated by the plan, and that no artificial lighting source is disrupting its proper operation.
Verify that the conduits are neatly routed and fasten securely in place.
Verify that enclosures are securely mounted.
Verify that enclosure covers are in place and that fasteners for the covers have had anti-seize or grease worked into the threads.
Verify that moving parts of the switch gear have been lubricated and operate smoothly.
Verify that no debris has been left in enclosures and that the wiring in each enclosure is neat, orderly and tied into place where appropriate.
1150-12 **Grounding**

1150-12.1 **General**

The conducting portions of those items containing electrical conductors are to be connected to each other and to earth electrodes to lessen the chance of injury and damage from unwanted electrical currents. Connecting the various conducting portions together to form the continuous path for the flow of stray electrical currents, often referred to as bonding, in ODOT'S projects is generally an incidental to the construction. Installation of the earth electrodes and the connection of the conducting portions to those electrodes is often referred to as grounding and in ODOT’S projects payment is somewhat related to the electrodes installed.

1150-12.2 **Ground Rods**

Verify that the ground rods specified have been installed. When additional rods have been added to lower the resistance, verify that the installation of each rod was approved prior to its installation.

Verify that the connection between the ground rod and the grounding cable is an exothermic weld. When additional rods have been added to reduce the resistance, verify that the additional connections are exothermic welds.

The normal ground rod item is for one rod driven into earth and the lead between the rod and the first connection and the associated connections. The earth resistance is then checked. When said resistance exceeds the specified limit, an additional rod is to be driven and connected to the first. The earth resistance of the pair is then checked. The process is repeated until the resistance of the group is lower than the specified limit. Payment is then made at the per rod price for each rod installed.

ODOT has reserved the right to approve the use of each additional rod before it is installed and may decline to install additional rods; thereby stopping the process at any point. When ODOT stops the installation of additional rods, it may decide to take another course of action to lower the earth resistance. If no additional action is taken, then by default the earth resistance becomes acceptable as it stands.

1150-12.3 **Exothermic Welds**

An exothermic weld often has a rougher surface texture on the weld metal than one may be used to seeing, but the weld is not to have other signs of a poor quality weld such as porosity, cratering, cracking or undercutting.

1150-12.4 **Structure Grounding**

Verify that each grounding electrode is acceptable before structure construction makes modification of the electrode or the installation of additional electrodes along side impractical. Remember that if some of the electrodes are driven rods, that such rods are incidental to the structure grounding system, not separate items. However, if due to high resistance, additional rods are driven, those rods are not incidental to the structure grounding system.

Verify that the necessary bonding jumpers are in place and functioning correctly before structure construction makes the installation of additional jumpers impractical.

Structures present special needs. Not only is it not practical to have a separate ground rod for each light pole or similar item mounted upon the structure, but also there are elements of the structure itself that need grounding. Thus the normal practice is to use bonding jumpers to connect all exposed metal items together and thence to the several electrodes frequently utilizing the main conducting portions of the structure as the main grounding buss. This means that electrodes are often under footers and bonding jumpers are frequently embedded in the structure. If something is left out or does not function as intended and it is not discovered until the final stages of construction, the grounding can become expensive, unsightly and less than desired. Unfortunately, structure designers all to often include little in the way of specific details for the structure grounding. Therefore, it is imperative to be constantly thinking ahead to fully understand where each electrode and jumper is to be located and to verify that it is in place.
and functioning correctly at each stage.

### 1150-12.5 Bonding Along Circuits

Verify that all of the conducting items containing the conductors of each circuit are bonded to form a continuous path back to the source of the circuit.

- At light poles, verify that metal conduits entering the base of the pole are bonded to the pole.
- At pull boxes, verify that the metal conduits entering the pull box are bonded together and that the metal lid and lid frame are bonded to the metal conduits.
- At junction boxes, verify that the metal conduits entering the junction box are bonded to the box.
- At the expansion and deflection joints in conduits of conducting materials, verify that a bonding strap has been install across the joint.

When non-conducting conduit or duct is used, verify that a grounding conductor has been installed to provide for the continuous grounding path when necessary.

### 1150-13 Wiring and Cabling

#### 1150-13.1 General

Field wiring of highway lighting circuits is broken into three types, pole and bracket cable, distribution cable and duct cable.

#### 1150-13.2 Pole and Bracket Cable

Pole and bracket cable is the insulated single conductor used in a light pole (but not in a light tower) to connect from the distribution cable, up the pole and out the bracket arm to the light fixture (in a tower the electrical wiring from the base of the tower to the luminaires is a component of the lowering device).

Verify that each run of cable is of the size and type specified. The wire size and insulation are to be indelibly marked on the insulating jacket at frequent intervals along the length of the cable.

Verify that each run of cable is installed in a continuous piece without inline splices between the terminations shown on the plan.

Verify that the insulating jacket was not nicked nor portions shaved away as the cable was pulled into place.

Verify that the cable was not stretched as it was pulled into place. If the cable can be pulled back and forth by hand enough to move both ends, stretching probably did not occur.

Verify that a cable support was installed at the upper end of the vertical run of cable up the pole.

Verify that there is enough length on each end of the run for the cable to be routed properly to its termination and still remain slack.

#### 1150-13.3 Distribution Cable

Distribution cable is the insulated single conductor used to construct lighting circuits from the control equipment of the power service to the disconnect kits of a light pole, the terminal block of a light tower, or the disconnect switch for underpass or sign lighting.

Verify that each run of distribution cable is of the size and type specified. The wire size and insulation are to be indelibly marked on the insulating jacket at frequent intervals along the length of the cable.

Verify that each run of cable is installed in a continuous piece without inline splices between the terminations shown on the plan.

Verify that the insulating jacket was not nicked nor portions shaved away as the cable was
pulled into place.

Verify that the cable was not stretched as it was pulled into place. If the cable can be pulled back and forth by hand enough to move both ends, stretching probably did not occur. Unfortunately, for the larger wire sizes and the longer runs commonly encountered in highway lighting circuits, the cable cannot be pulled by hand. Thus, the most common indication of stretching is when the length of pulling lead exiting the raceway is greater than the length of cable entering the raceway or the pulling forces are greater than normally encountered; both of which are not easily detected by other than experienced installers.

Verify that there is enough length on each end of the run for the cable to be routed properly to its termination and still remain slack.

All cables shall be labeled in accessible enclosures (pull boxes, hand holes, transformer base, device housing, etc.). A minimum of 5 feet of extra cable shall be provided for each conductor at all terminal points.

1150-13.4 Duct Cable

Duct cable consists of insulated conductors, of the type used for distribution cable, installed into a duct and shipped as an assembly to the project. It is used in place of conduit and distribution cable to speed the installation of underground circuits.

Verify that the temperature of the duct cable was above 32 degrees Fahrenheit throughout the installation process.

It is permissible to install duct cable when the outdoor air temperature is actually below those temperatures, but the Contractor must obtain authorization from the engineer. The contractor shall submit in writing his method of heating the duct cable and maintaining the duct cable at a uniform temperature throughout the installation process. To assure that the duct cable is heated uniformly, the heating process shall keep the temperature of the duct cable above 32 degrees Fahrenheit a minimum of 24 hours prior to installation. Under conditions such as the preceding where the temperature of the duct cable can be expected to vary widely during the installation process, the expansion and contraction of the duct cable must be taken into consideration. Typically, the duct cable length will decrease (or increase) 1 foot per 1000 feet for each 10 degree Fahrenheit decrease (or increase) in temperature.

Verify that the duct of the installed duct cable extends out of any conduit sleeve through which it passes enough to allow for the expansion and contraction in the duct due to seasonal changes in temperature. Typically a projection of 2 to 3 inches is appropriate at the usual installation temperatures for the lengths of run typical in ODOT'S installations.

As received on the reel from the manufacturer, it will appear that the cables inside the duct and the duct are equal in length but in reality the cables are shorter than the duct. In order to reel the assembly onto the shipping spool both the cables and the duct were anchored to the spool. As the duct cable assembly is unrolled from the shipping spool, the cables will be drawn into the duct resulting in empty duct at the start of the run. For the assemblies typically used in ODOT’s projects, leaving 25 feet of duct for each 1,000 feet of run to be installed at the start of the run, in addition to that required as slack for connections at the start of the run, will compensate for this. At the end of the run, only the slack amount for connections is required.

Verify that the insulating jacket of each cable within the duct has not been damaged when the duct was stripped to allow the connections to be made. Often the length of duct to be stripped is such that no protection can be slid over the cables and into the end of the duct which means that the cables within are saved from damage only by the skill of the person stripping the duct.

When a duct cable assembly has been passed through a conduit sleeve, verify that the duct has been sealed to each end of the sleeve by means of a molded boot or wrapped sealing pad.

Verify that the seal installed between the able and the duct is installed in the same location and in the same manner as outlined under the installation of distribution cable into conduits.

Verify that there is enough length on each end of the run for each cable to be routed properly to its termination and still remain slack.
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1150-13.5 Conductor Identification
At each access point (pole base, pull box, junction box, switch gear enclosure, etc.) each conductor of each run of the field wiring (pole and bracket cable, distribution cable, duct cable) of each circuit is to be identified by applying a tag to the conductor indelibly marked to indicate the circuit and the use of that conductor within the circuit.

1150-14 Connections

1150-14.1 General
This covers the connection of the field installed wire and cable to other such wire and cable and to the various items of equipment.

1150-14.2 Sizing Conductor to Device Terminal
When the circuit conductor is of a larger size than the device terminals can accommodate, verify that the connection has been made by splicing a short piece of smaller wire onto the end of the large wire and then connecting the smaller wire to the device terminal. The smaller wire is normally identical to the larger wire in all aspects except for size. The smaller wire must be large enough to carry the current that the circuit protection will allow. It is not acceptable to cut back some of the strands of a conductor, so that the remaining stranded will fit into the terminal.

1150-14.3 Crimped Compression Connections
Verify that the die in the compression tool was for the connector applied and that the connector is sized to match the wire to which it was applied and that the tool used was of a type that did not release the connector from the die once compression started until full compression was achieved.

1150-14.4 Pull-Apart and Bolted Connections
Verify that the internal connector is properly applied to the conductors.
Verify that the insulating cover was cut to proper step for a snug fit over the insulation on each entry to the housing.
Verify that the internal parts are all present in good condition and are fully seated into the housing.
Verify that the male half of the housing is a snug fit and fully inserted into the female half of the housing.
Verify that a thin coating of the kit manufacturer's approved non-conducting grease has been used at the joint between the two halves of the housing, between the housing and each cable entering the housing, and on other internal parts as shown in the manufacturer’s instructions, to allow the parts to slide smoothly into place and help seal out water.
Verify that there are no sharp bends in each cable where the cable enters the housing sufficient to cause the housing to pull away from the insulating jacket on the cable.
When the kit is to contain a fuse, verify that the fuse is of the proper ampacity.
Where the kit contains bolted connections, verify that the connections were properly tightened before the housing was closed.
Verify that there is sufficient slack in the cables being connected to permit bringing the connector kit outside of the pole, transformer base or junction box in which it is housed for servicing.

1150-14.5 Unfused Permanent Connections
Verify that the internal connection is via a proper crimp compression connector.
Verify that the mold surrounding the connection is completely filled with resin.
Verify that the connection is positioned within the mold such that the resin properly surrounds the connection.

Verify that there are no voids in the resin.

Verify that no fillers have been used.

Verify that the resin has properly set.

1150-15 Test Procedures

1150-15.1 General

There are a number of tests normally utilized to ascertain that the lighting installation has been well constructed and is in good operational order. For a particular test to have meaning, it must be properly conducted and the results properly interpreted.

Verify that the equipment used to conduct the test is in working order and calibration.

1150-15.2 Grounding Electrodes

Verify that each specific grounding electrode meets the requirements of the earth resistance test.

The first key to conducting a successful test of a grounding electrode is to understand what constitutes the electrode. A single driven rod is an electrode. When that rod fails the earth resistance test and another rod is added, the electrode then becomes both rods together. However, in the case of a light tower where two rods are typically specified, the initial electrode is the two rods together rather than each rod separately. In structure grounding, the cluster of driven piles at the end of a pier footer should be considered as a single electrode with the cluster at the other end of that same footer considered as a separate electrode. A continuous grid of mesh, bars or cables laid beneath a footer is one electrode, but separate grids under different portions of the same footer are separate electrodes. Wires buried in a radial pattern from a single pole constitute an electrode.

The second key to successful ground resistance is to understand the limitations of the various test instruments and procedures. The chosen procedure must be appropriate for both the electrode under test and the conditions in which the electrode is installed, and the instrument must be capable of producing valid results for the situation at hand.

1150-15.3 Circuit Continuity

The key to the proper checking of circuit continuity is to remember the objective and to test one conductor at a time. The objective is to see that the conductor is connected to the desired device point and that the conductor has not been connected to any other devices. The difficulty is that the devices are scattered over a large area thus requiring the other conductors of the same circuit to be used as returns for the test signal. For the test to be of use often means that testing must start at one node in the circuit and test all connections along an isolated link from that node. Additional nodes and links are then added one at a time and the continuity of the conductors rechecked until the entire circuit has been verified.

1150-15.4 Cable Insulation

This test is designed to verify that the insulation of each conductor in the circuit and permanent and bolted connections in that conductor are in good conditions by impressing a much higher than normal voltage on the conductor using the change in leakage current over time. Care must be used not to impress the test voltage on devices normally connected by the circuit since the devices would probably be damaged. Since the other conductors in the circuit must often be used as the return path, it is necessary to use care to ensure that the other conductors are not damaged while serving as signal returns and careful interpretation of the results to determine whether the leakage is from a conductor failing the test or from a failure in the return path.
1150-15.5 Lowering Device Operation

This test is simply repeated operation of the lowering device on a light tower to verify that it operates smoothly and correctly throughout its full range cycle of motions.

1150-15.6 System Performance

The test uses the concept “Infant Mortality” to determine if the equipment is likely to operate satisfactorily throughout the projected life of the installation. The concept is the equipment is most likely to fail from manufacturing defects and installation in the first few hours of use and that once these hours are past it is likely to run the rest of its life with only normal maintenance. In conducting the test, it is important to recognize the significance of each component malfunction encountered and to properly interpret whether the malfunction indicates a need to extend the test period.

1150-16 Provide Information to Maintaining Agency

Ensure that each maintaining agency receives the documents pertinent to the maintenance and operation of the lighting units for which it is responsible. Typically included are:

1. A copy of the plan marked to show any changes made during the construction.
2. A copy of each certified drawing.
3. A copy of each instruction or parts manual supplied by each manufacturer.

1150-17 Documentation Requirements

1. Luminaires
   a. Each luminaire has the distribution, lamp and aiming stipulated in the Contract Documents.
   b. Each luminaire has been “leveled”.

2. Supports
   a. Each support is the one stipulated for that location by the Contract Documents.
   b. Each support is comprised of the correct components according to the certified shop drawings.

3. Pull boxes
   a. Each pull box is the size and type stipulated for that location by the Contract Documents.
   b. Each pull box supplied under plant sampling and testing program, that it has a TE 24.
   c. Each drain is documented on form CAP 1.

4. Conduit
   a. The conduit is the size stipulated for that location by the Contract Documents.
   b. The conduit is of the material stipulated for that location by the Contract Documents.
   c. The measurement of the length installed.

5. Trench
   a. The location and depth is as stipulated by the Contract Documents.
   b. There are no sharp rocks in backfill adjacent to duct.
   c. The backfill is placed in 4-inch lifts and mechanically tamped.
   d. The measure length installed.

6. Grounding electrodes
   a. Each electrode is installed as stipulated for that location by the Contract Documents.
   b. Each grounding conductor is connected to ground rod with exothermic weld.
   c. Each document ground resistance.

7. Wire and Cable.
   a. Wire size and insulation is as stipulated for that location by the Contract Documents.
   b. Measurement of the length installed.
1160-1 General

It is not enough to simply install highway lighting and leave it exposed to the ravages of the elements. The public expects ODOT to protect the dollars invested in the lighting by making sure that the lighting is operable so that it can be used by those traveling the highway when natural light is inadequate. This chapter addresses ODOT's lighting maintenance policies and practices.

The District Highway Management Administrator through the Roadway Services Manager is responsible for ensuring that highway lighting units that ODOT is responsible for within the District are in proper operating order. The physical work required to fulfill this responsibility may be contracted out to other governmental entities, utility companies and private contracting companies, or performed by ODOT forces.

1160-2 Lighting Maintenance Practice Process

A contact point shall be established by each District for receiving notification from law enforcement personnel, emergency response and maintenance units, other governmental entities, utility companies, and the traveling public of damage to, and malfunction of, highway lighting. Periodic inspection of lighting installations shall also be made.

The information obtained from these notifications and inspections shall be used to document the damage or failures, and the date of discovery. Based on the nature of the damage or failure, the District Roadway Services Manager will ensure that the appropriate responses are made, the incident tracked until repairs have been completed, and the date of completion of repairs documented.

Each District shall also see that preventive maintenance is performed to forestall failures, to facilitate repairs during responses to damage and failure, and to provide proper general housekeeping of the installations.

The use of “hot sticks” is not allowed.

1160-3 Determination of Responsibility

1160-3.1 ODOT and Local Jurisdictions

To avoid conflicts during design and construction, planners should included the lighting responsibility in the project scope, since the designer must split the electrical service and circuits between the various agencies. Unless transferred to another entity by a properly executed and approved agreement, the responsibility for the maintenance of, and energy for, the operation of each highway lighting unit is as shown in Table 1197-12.

The responsible party may through an approved agreement or contract arrange for another party to provide materials and equipment, and to perform the actual work. However, agreements and contracts to provide materials and to perform the actual work shall not transfer the responsibility.

1160-3.2 ODOT and the Power Companies

1. Overhead Power Feed via a Weatherhead
   a. ODOT is responsible for the circuit from the weatherhead into the control center and subsequent lighting circuits.
   b. If the circuit is damaged between the weatherhead and the control center, or within the control center itself, ODOT must contact the power company to shut off the power feed so ODOT forces can make necessary repairs. Once repairs are complete, the power company shall be contacted to turn the power service back on.
   c. If the circuit is damaged down from the control center, the power shall be shut off at the control center by ODOT forces, and perform lock-out, tag-out procedures, and proceed repairing the circuits.
d. No work shall be performed on live circuits.

2. Underground Power Feed
   a. ODOT is responsible for the circuit from and including the control center.
   b. If the control center is damaged, the power company shall be contacted to shut off the
      power prior to any repair work being done.
   c. If the circuit is damaged down from the control center, the power shall be shut off at the
      control center by ODOT forces, and perform lock-out, tag-out procedures, and proceed
      repairing the circuits.
   d. No work shall be performed on live circuits.

1160-4 Emergency Maintenance
Downed or damaged supports that could pose a danger to the traveling public shall be removed as
soon as practical, either off the right-of-way or outside the clear zone as defined by the L&D Manual
Volume 1, Chapter 600.
Exposed live wires shall be secured as soon as possible after discovery.

1160-5 Reactive Maintenance
The maintenance operations are expected to keep the number of working luminaires at a
satisfactory level.
To be considered as working, a luminaire must not only be lighted but must be properly aimed. A
satisfactory level is when the total number of working luminaires meets or exceeds 90 percent of
the total number of luminaires for which the District is responsible.

1160-6 Periodic Inspection
Each District should periodically inspect all highway lighting units and sign lighting luminaires for
which it is responsible. This shall include the units maintained using District forces, as well as
those maintained for the District by other entities such as contractors, power companies or cities.

1160-7 Required Preventive Maintenance
Exposed Equipment - Each cover on a support, junction box, pull box, or piece of power service
switch gear shall be secured in the closed position. Any such cover which is missing shall be
replaced. Fence gates shall be secured in the closed position.

1160-8 Recommended Preventive Maintenance
Re-lamping - Sodium vapor (highway lighting) lamps should not remain in service longer than four
years, as measured by the date code marked on the lamp at the time of installation.
Housekeeping - The following preventative maintenance measures are recommended while
performing spot maintenance work and should be performed annually on those pieces of equipment
that did not receive the measures during the previous twelve months as part of spot maintenance.
1. Whenever a moving part, latch or lock is accessed it should be lubricated, if in need. For
   lubrication of electrical switchgear parts, such as those found in power service disconnects and
   lighting control centers, the Office of Roadway Engineering (ORE) recommends use of CRC
   HV Switchgear Lubricant, Part # 02060. Make sure electrical equipment is de-energized before
   using aerosol lubricant sprays. For lubrication of enclosure door gaskets, ORE recommends
   3M Silicone Lubricant spray (UPC 021200-85822). For lubrication of padlocks and key-lock
   mechanisms, ORE recommends an extra-fine dry powdered (not dry-film) graphite such as
   Superior Graphite Tube-O-Lube.
2. Whenever a threaded cover fastener is accessed, an appropriate anti-seizing agent should be
   applied or redistributed.
3. Damaged or missing fasteners should be repaired or replaced.
4. Debris should be removed from in and around the base of each light pole and vegetation cut
   back. Debris and vegetation cuttings should be properly disposed and not left piled at the site.
5. For frangible poles, adjustments to grade should be made to ensure that the pole foundation is flush with grade on the up slope side, and that the top of the foundation is not below grade.

6. For non-frangible poles, adjustments to the grade should be made to ensure that the top of foundation is above grade.

7. Debris should be removed from in and around each power service (and power service enclosure fence, if used) and vegetation cut back. Debris and vegetation cuttings should be properly disposed and not left piled at the site. Debris should be removed from in and around each pull box and the grade adjusted whenever the pull box is opened. Debris and vegetation cuttings should be properly disposed and not left piled at the site.

8. Eroded and sunken areas adjacent to foundations pull boxes and control sites, or over cable trenches, should be filled, seeded and covered with erosion resistant material to slow the flow of runoff and promote vegetative growth.

1160-9 Replacement Luminaires

A replacement luminaire should be of such similar photometric distribution that the intensity and uniformity of the lighting system is not unduly compromised from the installed design. In addition, the weight and effective area of the replacement luminaire shall not exceed the capacity of the support. Where the support is equipped with a mechanical device for lowering the luminaires, the luminaires shall be replaced in the quantity needed to keep the mechanism in balance if necessary.

Replacement supports shall maintain the luminaire mounting height and overhang or underhang.

1160-10 Failure Analysis

The District should use historical inspection reports to discover locations experiencing repeated knock downs, pull box locations with repeated cover or box damage, or other patterns of damage that may suggest mitigating actions.

1160-11 Repairing Broken Conduit and Duct Cable

1160-11.1 General

The following procedures should be followed when performing repairs on an existing electrical system.

All damaged cables shall be replaced, except when the distance between terminal points is determined to be excessive in length. In this case pulling of new cables is not recommended because the cable insulation may be damaged. The repair should be accomplished by strategically installing a new pull box to minimize the length of cable to be replaced. Cable splice kits, as specified in C&MS 725.15, will be stored in the pull box.

No direct buried splices are allowed. No splices are allowed inside the duct since that violates the National Electric Code.

1160-11.2 Repair Damaged Duct Cable

Duct cable repair shall be accomplished by splicing the duct at the break point in one of the following methods:

Repair with Compression Fittings.

After the duct break is exposed, the damaged cable shall be removed. The duct is prepared for splicing by cutting the duct square to remove the rough edges off each end of the duct. Use either a hacksaw or plastic pipe cutter. Burrs shall be removed from the cut ends and the duct cleaned of dust, dirt, etc. Two compression fittings (such as E-lock or Duraline’s Comfit) and a short length of duct are needed to complete the repair. One compression fitting is placed on each cut end and the length of duct is fit between the two fittings. Test fittings to make sure the duct fit is tight. Pull in new wire and complete cable connections.

Repair with PVC Coupling.

PVC couplings use a standard piece of Schedule 40 PVC conduit to replace the missing
section of duct cable. After the duct break is exposed, the damaged cable shall be removed. The duct is prepared for splicing by cutting the duct square to remove the rough edges off each end of the duct. Heat shrink tubing should be placed over the PVC before the duct cable is inserted in the PVC coupling. The PVC coupling shall be sufficiently long to replace the missing section of duct. Heat shrink tubing shall extend at least 6 inches on each side of each seam. Heat shrink tubing should be heated with a heat gun or hair dryer. Applying heat with an open flame will damage the tubing and shall not be permitted.

PVC cement will not adhere to duct cable and should not be used.

1160-11.3 Repair PVC Conduit

PVC conduit shall be repaired using PVC couplings and PVC cement in the procedures normally followed during initial installation.

1160-11.4 Repair Rigid Conduit

Rigid conduit shall be repaired using rigid conduit and threadless couplings.

1160-12 Troubleshooting Lamps

1160-12.1 General

Before attempting any troubleshooting, the electrician should verify the circuit operation and path. Lock out/tag out procedures and other safety procedures for 480 volt systems should be followed and documented. The following sections outline possible causes and corrective action for various problems.

1160-12.2 Lamp Will Not Start

<table>
<thead>
<tr>
<th>Possible Causes</th>
<th>Corrective Maintenance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lamp loose in socket.</td>
<td>Screw lamp firmly into socket until good contact is made. STOP! Excess torque may cause lamp to shatter at neck.</td>
</tr>
<tr>
<td>Incorrect lamp.</td>
<td>Check and compare data on ballast or fixture nameplate with lamp electrical characteristics.</td>
</tr>
<tr>
<td>Incorrect or loose wiring.</td>
<td>With power off, check wiring against wiring diagram; check for loose connectors and loose terminal screws; check for broken insulation. Check circuit continuity with ohm meter.</td>
</tr>
<tr>
<td>End of ballast life.</td>
<td>Check for charred spots and/or swollen capacitors.</td>
</tr>
<tr>
<td>Photoelectric control</td>
<td>With power ON, cover photocell. Wait the few minutes generally required for an operative photocell to apply power to the fixture. Replace if inoperative.</td>
</tr>
<tr>
<td>inoperative.</td>
<td></td>
</tr>
<tr>
<td>Supply voltage to fixture</td>
<td>Check supply voltage and ballast output voltage.</td>
</tr>
<tr>
<td>or ballast output voltage</td>
<td></td>
</tr>
<tr>
<td>is low.</td>
<td></td>
</tr>
<tr>
<td>HPS starter circuit failure.</td>
<td>Check lamp on Discharge Lamp Checker or try known good lamp. Replace starter.</td>
</tr>
</tbody>
</table>

1160-12.3 Short Lamp Life

<table>
<thead>
<tr>
<th>Possible Causes</th>
<th>Corrective Maintenance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Incorrect lamp.</td>
<td>Check and compare data on ballast or fixture nameplate with lamp electrical characteristics.</td>
</tr>
<tr>
<td>Shorted ballast.</td>
<td>Check electrically for a shorted ballast.</td>
</tr>
<tr>
<td>Over wattage operations.</td>
<td>Check ballast or fixture rating for lamp type and wattage. Check operation for correct voltage and current at socket terminals.</td>
</tr>
</tbody>
</table>
1160-12.4 Flickering

**Possible Causes**

- Supply voltage to fixture is low.
- Incorrect ballast.
- High operating voltage.
- Low ballast output voltage.
- Variable voltage.
- Bad lamp.
- Loose wiring.

**Corrective Maintenance**

- Check both supply and ballast output voltage with lamp operating.
- Check and compare data on ballast or fixture nameplate with lamp electrical characteristics.
- Check lamp voltage at socket terminals while operating.
- Check ballast output and supply volts without lamp in circuit.
- Use recording voltmeter to check degree and duration of voltage variation. Check to determine other electrical loads on lamp circuit. Remove lighting circuit from lines with large electrical loads.
- Replace lamp.
- Check wire connections.

1160-12.5 Blown Fuses

**Possible Causes**

- High momentary line current at turn “ON.”
- Overloaded circuit.
- Shorted wires.
- Old or worn fuses.
- Lightning induced peak.

**Corrective Maintenance**

- Check ballast literature for recommended rating of circuit protective devices. Circuit protective devices should have time delay elements when used with reactor or auto-transformer ballasts.
- Check total load on circuit; lamps and ballasts plus other connected equipment.
- Locate shorted wires and repair.
- Replace with new and correct fuses.
- Replace fuse. Check for other damage.

1160-12.6 Lamp Light Output Low

**Possible Causes**

- Lamps near end of life.
- Supply voltage to fixture is low.
- Incorrect ballast
- Low ballast voltage.
- Dirt accumulation.
- No refractor.

**Corrective Maintenance**

- Replace lamp.
- Check both supply and ballast output voltage with lamp operating.
- Check and compare data on ballast or fixture name plate with lamp electrical characteristics.
- Check ballast output and supply volts without lamp in circuit.
- Clean luminaires and lamps.
- Install refractor.

1160-12.7 Lamp Starts Slowly

**Possible Causes**

- Supply voltage to fixture is low.
- Low ballast output voltage.
- Lamp is defective causing a hard start.

**Corrective Maintenance**

- Check both supply and ballast output voltage with lamp operating.
- Check both ballast output and supply volts without lamp in circuit.
- Replace lamp IF other system components are OK.
**Possible Causes** | **Corrective Maintenance**  
--- | ---  
Incorrect ballast. | Check and compare data on ballast or fixture name plate with lamp electrical characteristics.  
Lamp life used up. | Replace lamp.  
Low voltage at socket. | Check ballast for voltage.  

**Possible Causes** | **Corrective Maintenance**  
--- | ---  
Low supply voltage. | Check supply voltage and ballast output voltages with lamp operating.  
Low ballast output. | Check ballast output and supply volts without lamp in circuit.  
Variation in light distribution. | Check luminaire. To test, interchange lamps between suspected and normally performing luminaires. Check refractor and glass lens.  
Dirt accumulation. | Clean luminaires and lamps.  
Illumination color differences. | Variations in environmental color-walls, tunnels, bridges, etc., can cause illumination-color illusions.  

**Possible Causes** | **Corrective Maintenance**  
--- | ---  
Control Center problems. | Check supply voltage and output voltage. Check fuses. Check contactor.  

**1160-13 Pole Replacement/Foundation Repair**

**1160-13.1 General**

Before new poles and transformer bases are installed on existing foundations they shall be checked for the following:

1. Anchor bolt threads shall not show signs of excessive rusting that could later deteriorate to a point where they could become a safety hazard should they fail.
2. Foundation concrete does not indicate excessive deterioration whereby it is impossible for the transformer base to be properly installed and leveled.
3. Check to determine if the foundation has shifted or tilted to the extent that the pole cannot be properly plumbed.
4. Top of foundation shall not protrude above ground level on the upslope side.
5. All painted light poles shall be checked for excessive rusting. If it is determined that they are unsafe, they should be replaced with either new or used galvanized steel or aluminum poles.
6. Pull boxes extending more than 1 inch above the existing grade should be reset, flush with the existing grade level.

When a light pole falls down, the pole and foundation should be inspected and the best method for repairing the installation determined. If a material deficiency in the pole or foundation was fully or partially responsible for the failure, the materials should be examined closely for defects, corrosion and vandalism. The probable cause of the failure should be noted.

When a pole falls, the simplex weld for the bracket arm should be inspected by looking down the inside of the top of the pole to see if the impact has cracked the weld. If the weld is cracked, the pole should not be reinstalled.

**1160-13.2 Anchor Bolts Sheared**
Standard light pole foundations can be repaired by jack hammering out the concrete to 1 foot below grade, using threaded couplings and threaded bolt extensions on the anchor bolts, recapping the foundation (with the threaded coupling encased in concrete), and erecting a new pole/base.

It is also possible to extend the anchor bolts with a special cadweld instead of threaded couplings. The bolt extension could be welded on and the weld embedded in the new concrete. Welded extensions would be necessary if the remaining anchor bolt did not have enough thread to receive the threaded coupling. This may also be necessary if repairing a tower foundation. In the case of welding on bolts, the concrete foundation would likely need to be removed to a depth greater than 1 foot below grade.

**1160-13.3 Anchor Bolt Bent**

When a bolt is bent by the impact of a knockdown, it can be repaired by straightening the bolt using physical force (sledgehammer) or by heating it. Consider the location of the bolt (tension or compression side) and the amount of bending necessary when assessing if a repair is possible. If the concrete around the anchor bolt has been cracked by the impact, consider replacing the foundation.

**1160-13.4 Cracked Concrete in Foundation**

Most cracked foundations should be replaced with new foundations. A repair would involve removing the concrete at least 1 foot below grade and recapping the foundation.

**1160-13.5 Anchor Bolt Adapter Plates**

When a foundation has a unique anchor bolt configuration which is not matched by any other current pole manufacturer, the foundation can be used for a new pole by manufacturing a specialized anchor bolt adapter plate. The adapter plate would mount on the existing bolts and provide a new bolt circle (typically 15-inch bolt circle) for mounting a new pole.

**1160-14 Bracket Arm Repairs**

When a bracket arm falls down, the pole and arm should be inspected to determine the best method for repairing the installation. If a material deficiency in the pole or arm was fully or partially responsible for the failure, the materials should be examined closely for defects, corrosion and vandalism. The probable cause of the failure should be noted.

Replacement bracket arms should closely match the style, length and rise of the bracket arm being repaired.

Before installing a replacement arm on an existing simplex hanger, the simplex weld should be inspected by looking down the inside of the top of the pole to see if the weld is cracked. If the weld is cracked, the arm should not be installed on that hanger. Bracket-type or banding-type attachments should be used instead.

If the arm fell because the simplex bolt sheared off, but the hanger and weld are in good condition, the bolt hole can often be redrilled and a new bolt installed.
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1197-1 Suggested Data for the District System Lighting Plan

As noted in Chapter 1101, Table 1197-1 lists suggested data for use in preparing the database used to develop a District System Lighting Plan (DSLP).

1197-2 Codes for Use in the District System Lighting Plan

As noted in Chapter 1101, Table 1197-2 lists codes to be used in the DSLP.

1197-3 Warrants for Freeway and Interchange Lighting

As noted in Chapter 1103, Table 1197-3 lists warrants for freeway and interchange highway lighting.

1197-4 Average Maintained Luminance Design Values

As noted in Sections 1103-4, 1106-1, 1106-2.2, 1140-3.1 and 1140-3.6.2, Table 1197-4 shows average illuminance design values.

1197-5 Nominal Mounting Height and Wattage

As noted in Section 1140-4.3.2, Table 1197-5 shows mounting heights with wattages.

1197-6 Typical Bracket Arm Lengths

As noted in Section 1140-4.3.4.2, Table 1197-6 shows typical bracket arm lengths.

1197-7 Recommended Conduit Sizes

As noted in Section 1140-5.5.2, Table 1197-7 shows recommended conduit sizes.

1197-8 Lighting Load Table

Table 1197-8 shows a sample circuit lighting load table.

1197-9 Recommended Lateral Soil Pressures for Foundations

As noted in Section 1140-8, Table 1197-9 shows recommended soil pressures for foundations.

1197-10 Foundation Embedment Nomograph

As noted in Section 1140-8, Table 1197-10 shows the recommended depth for foundation embedment.

1197-11 Allowable Lateral Soil Resistance

As noted in Section 1140-8, Table 1197-11 shows allowable lateral soil resistance based on tower height.

1197-12 Determination of Responsibilities

As noted in Section 1160-3, Table 1197-12 shows maintenance and energy responsibilities for highway lighting.
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<table>
<thead>
<tr>
<th>Luminaires</th>
<th>Pole or Tower</th>
<th>Control Center</th>
<th>Circuits</th>
<th>Maintenance Costs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Voltage</td>
<td>Tower or Pole Number</td>
<td>Energy</td>
<td>Number</td>
<td>Energy Units Consumed</td>
</tr>
<tr>
<td>No. of Units</td>
<td>Height</td>
<td>Power Company</td>
<td>AWG</td>
<td>Lamp Life Cycle</td>
</tr>
<tr>
<td>Manufacturer</td>
<td>Foundation Diameter &amp; Depth</td>
<td>Capacity</td>
<td>Two or Three-Wire</td>
<td>Direct Labor</td>
</tr>
<tr>
<td>Wattage</td>
<td>Manufacturer</td>
<td>Service Type</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ballast</td>
<td>Lowering Device Type</td>
<td>Supply Voltage</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Shields</td>
<td>Bracket Arm Length</td>
<td>Voltage</td>
<td></td>
<td></td>
</tr>
<tr>
<td>IES Distribution</td>
<td>Pole Base Type</td>
<td>Amperage</td>
<td></td>
<td></td>
</tr>
<tr>
<td>IES Photometric #</td>
<td>Installation Year</td>
<td>Meter</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Re-lamp Date</td>
<td>Control center</td>
<td>Latitude &amp; Longitude</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Circuit number</td>
<td>Owner or Maintaining Agency</td>
<td>Control Center</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Latitude &amp; Longitude</td>
<td>Control Center ID Number</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Code</td>
<td>Description</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>------</td>
<td>-------------</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>B - Blue</strong></td>
<td>Isolated intersections which are not part of an interchange.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>G - Green</strong></td>
<td>Interchanges which have partial interchange lighting.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>O - Orange</strong></td>
<td>Interchanges which have full interchange lighting.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>P - Pink</strong></td>
<td>Roadways which are not within an interchange area, but which are between interchanges or intersections which have continuous lighting.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>F - Future</strong></td>
<td>Unlighted locations to be lighted.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>U - Upgrade</strong></td>
<td>Lighted locations to received more comprehensive lighting (e.g., partial interchange to full interchange).</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>D - Downgrad</strong></td>
<td>Lighted locations to be downgraded to less comprehensive lighting (e.g., full interchange to partial interchange).</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>R - Remove</strong></td>
<td>Lighted locations to become unlighted.</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
### Table 1197-3. Warrants for Freeway and Interchange Lighting

| Continuous Freeway Lighting (CFL)¹ (CFL-1 and CFL-2 must both be satisfied) |
|-------------------------|---------------------------------------------------------------------------------------------------|
| Case CFL-1             | Requires 60,000 or more ADT and three or more through lanes in each direction                    |
| Case CFL-2             | Requires that three or more interchanges be located with an average spacing of 1.5 miles or less.|
| Case CFL-3             | Not used.                                                                                     |
| Case CFL-4             | Not used.                                                                                     |

| Complete Interchange Lighting (CIL) (Except per CIL-1 and CIL-2 below, new CIL should be installed only as an upgrade to existing PIL) |
|-------------------------|-----------------------------------------------------------------------------------------------|
| Case CIL-1              | The interchange is a System Interchange (freeway to freeway)                                  |
| Case CIL-2              | If one or more of the adjacent freeway segments qualify for CFL (Note 1)                       |
| Case CIL-3              | Not used.                                                                                     |
| Case CIL-4              | Not used.                                                                                     |

| Partial Interchange Lighting (PIL)² (All new Service Interchange lighting, when called for, shall initially be PIL, to be upgraded to CIL later if necessary) |
|-------------------------|-----------------------------------------------------------------------------------------------|
| Case PIL-1              | Requires that the average AADT ramp traffic entering and leaving the freeway at the interchange in question exceeds 2000. Ramps not meeting this AADT may remain unlit. |
| Case PIL-2              | Requires that the ADT for the through lanes on the freeway exceeds 35,000.                     |
| Case PIL-3              | Not used.                                                                                     |

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¹ Where there is continuous freeway lighting, there should be complete interchange lighting (CIL). If continuous freeway lighting is warranted, but not initially installed, then partial interchange lighting is considered to be justified under CFL-1 or CFL-2.

² Interchanges with side-by-side entrance/exit lanes (e.g., folded diamonds) or individual ramps with 2000+ ADT shall have ramp intersection lighting.

³ All volumes should be current or opening-day volumes.
### Table 1197-4. Average Maintained Luminance Design Values

<table>
<thead>
<tr>
<th>Roadway and Walkway Classification ²</th>
<th>Foot-Candles</th>
<th>Uniformity (avg./min.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Freeway (including ramps)³</td>
<td>0.9</td>
<td>3:1</td>
</tr>
<tr>
<td>Expressway (including ramps)³</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Commercial</td>
<td>1.3</td>
<td></td>
</tr>
<tr>
<td>Intermediate</td>
<td>1.1</td>
<td>3:1</td>
</tr>
<tr>
<td>Residential</td>
<td>0.8</td>
<td></td>
</tr>
<tr>
<td>Major³</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Commercial</td>
<td>1.6</td>
<td>3:1</td>
</tr>
<tr>
<td>Intermediate</td>
<td>1.2</td>
<td></td>
</tr>
<tr>
<td>Residential</td>
<td>0.8</td>
<td></td>
</tr>
<tr>
<td>Collector³</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Commercial</td>
<td>1.1</td>
<td></td>
</tr>
<tr>
<td>Intermediate</td>
<td>0.8</td>
<td>4:1</td>
</tr>
<tr>
<td>Residential</td>
<td>0.6</td>
<td></td>
</tr>
<tr>
<td>Local³</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Commercial</td>
<td>0.8</td>
<td></td>
</tr>
<tr>
<td>Intermediate</td>
<td>0.7</td>
<td>6:1</td>
</tr>
<tr>
<td>Residential</td>
<td>0.4</td>
<td></td>
</tr>
<tr>
<td>Sidewalks</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Commercial</td>
<td>1.3</td>
<td>3:1</td>
</tr>
<tr>
<td>Intermediate</td>
<td>0.8</td>
<td>4:1</td>
</tr>
<tr>
<td>Residential</td>
<td>0.4</td>
<td>6:1</td>
</tr>
<tr>
<td>Pedestrian Ways and Bicycle Paths⁴</td>
<td>2.0 (mixed ped, veh)</td>
<td>4:1</td>
</tr>
<tr>
<td></td>
<td>1.0 (ped only)</td>
<td></td>
</tr>
</tbody>
</table>

**Notes:**

1. Based upon R3 pavement classification, i.e. asphalt road surface, rough texture, Q₀ =0.07.

2. The terms “commercial,” “intermediate” and “residential” are defined in Section 1103-4. See Chapter 1301 for definitions of the other terms.


4. This assumes a separate facility. Facilities adjacent to a vehicular roadway should use the illuminance levels for that roadway.
Table 1197-5. Nominal Mounting Height and HPS Wattage

<table>
<thead>
<tr>
<th>Mounting Height (Nominal) Feet</th>
<th>Luminaire Rating (HPS Lamp Wattage)*</th>
</tr>
</thead>
<tbody>
<tr>
<td>32.5</td>
<td>200</td>
</tr>
<tr>
<td>35</td>
<td>200</td>
</tr>
<tr>
<td>40</td>
<td>200</td>
</tr>
<tr>
<td>50</td>
<td>310</td>
</tr>
</tbody>
</table>

* Lumens, not wattage, is the best rating method for LED luminaires, but a rough rule-of-thumb is that LED drop-in replacements for HPS luminaires will use almost 50% of the nominal HPS wattage.

Table 1197-6. Typical Bracket Arm Lengths (HPS)

<table>
<thead>
<tr>
<th>Location</th>
<th>Guardrail Offset Feet</th>
<th>Pole Offset Feet</th>
<th>Bracket Arm Length Feet</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mainline</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>16.5</td>
<td></td>
<td>18</td>
</tr>
<tr>
<td>12</td>
<td>18.5</td>
<td></td>
<td>20</td>
</tr>
<tr>
<td>Ramps</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>10.5</td>
<td></td>
<td>12*</td>
</tr>
<tr>
<td>6</td>
<td>12.5</td>
<td></td>
<td>15*</td>
</tr>
<tr>
<td>8</td>
<td>14.5</td>
<td></td>
<td>15*</td>
</tr>
</tbody>
</table>

*Shorter lengths should be considered on the inside of sharp curves, as discussed above.
### Table 1197-7. Recommended Conduit Sizes

<table>
<thead>
<tr>
<th>Usage</th>
<th>Nominal Size (ID) Inches</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pavement Crossovers</td>
<td>3</td>
</tr>
<tr>
<td>Bridge and Concrete Barrier Raceways</td>
<td>2</td>
</tr>
<tr>
<td>Longitudinal Conduit in Shoulder Areas</td>
<td>3</td>
</tr>
<tr>
<td>Structure Grounding - Embedded</td>
<td>1 1/4</td>
</tr>
<tr>
<td>Underpass Lighting Service</td>
<td>1 1/4</td>
</tr>
<tr>
<td>Conduit Ells</td>
<td>Same as connecting conduit, or 2 1/2 minimum for duct cable</td>
</tr>
<tr>
<td>Service Pole Pull Box to First Roadway Pull Box or Lighting Unit</td>
<td>3 (minimum)</td>
</tr>
</tbody>
</table>

### Table 1197-8. Lighting Load Table

<table>
<thead>
<tr>
<th>Circuit</th>
<th>Sign No. 5</th>
<th>Sign No. 7</th>
<th>Circuit No. 3</th>
<th>Sign No. 8</th>
<th>Sign No. 1</th>
<th>Sign No. 18</th>
<th>Circuit No. 12</th>
<th>Sign No. 13</th>
</tr>
</thead>
<tbody>
<tr>
<td>N</td>
<td>34 - 400 W</td>
<td>1 - 100 W</td>
<td>34 - 400 W</td>
<td>2 - 175 W</td>
<td>1 - 100 W</td>
<td>1 - 175 W</td>
<td>2 - 175 W</td>
<td>4 - 175 W</td>
</tr>
<tr>
<td></td>
<td>13,600</td>
<td>350 W</td>
<td>13,600</td>
<td>350 W</td>
<td>1,225 W</td>
<td>14,950 W</td>
<td>700 W</td>
<td>14,950 W</td>
</tr>
<tr>
<td>S</td>
<td>34 - 400 W</td>
<td>1 - 100 W</td>
<td>34 - 400 W</td>
<td>1 - 175 W</td>
<td>1 - 100 W</td>
<td>1 - 175 W</td>
<td>2 - 175 W</td>
<td>1 - 175 W</td>
</tr>
<tr>
<td></td>
<td>13,600</td>
<td>350 W</td>
<td>13,600</td>
<td>350 W</td>
<td>1,225 W</td>
<td>14,950 W</td>
<td>700 W</td>
<td>14,950 W</td>
</tr>
<tr>
<td>E</td>
<td>34 - 400 W</td>
<td>2 - 175 W</td>
<td>34 - 400 W</td>
<td>1 - 175 W</td>
<td>1 - 100 W</td>
<td>1 - 175 W</td>
<td>2 - 175 W</td>
<td>1 - 175 W</td>
</tr>
<tr>
<td></td>
<td>13,600</td>
<td>350 W</td>
<td>13,600</td>
<td>350 W</td>
<td>1,225 W</td>
<td>14,950 W</td>
<td>700 W</td>
<td>14,950 W</td>
</tr>
<tr>
<td>W</td>
<td>28 - 400 W</td>
<td>1 - 100 W</td>
<td>28 - 400 W</td>
<td>1 - 175 W</td>
<td>1 - 100 W</td>
<td>1 - 175 W</td>
<td>2 - 175 W</td>
<td>1 - 175 W</td>
</tr>
<tr>
<td></td>
<td>11,200</td>
<td>300 W</td>
<td>11,200</td>
<td>300 W</td>
<td>1,225 W</td>
<td>14,950 W</td>
<td>700 W</td>
<td>14,950 W</td>
</tr>
</tbody>
</table>
# Table 1197-9. Recommended Lateral Soil Pressures for Foundations

<table>
<thead>
<tr>
<th>CLASS OF MATERIAL</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rock in Natural Beds - Limited by the Stress in the Pile</td>
<td></td>
</tr>
<tr>
<td>Compact Well Graded Gravel</td>
<td>400</td>
</tr>
<tr>
<td>Hard Dense Clay</td>
<td>400</td>
</tr>
<tr>
<td>Compact Coarse Sand</td>
<td>350</td>
</tr>
<tr>
<td>Compact Coarse and Fine Sand</td>
<td>300</td>
</tr>
<tr>
<td>Medium Stiff Clay</td>
<td>300</td>
</tr>
<tr>
<td>Compact Fine Sand</td>
<td>250</td>
</tr>
<tr>
<td>Ordinary Silt</td>
<td>200</td>
</tr>
<tr>
<td>Sandy Clay</td>
<td>200</td>
</tr>
<tr>
<td>Compact Inorganic Sand and Silt Mixtures</td>
<td>200</td>
</tr>
<tr>
<td>Soft Clay</td>
<td>100</td>
</tr>
<tr>
<td>Loose Organic Sand and Silt Mixtures and Muck or Bay Mud</td>
<td>0</td>
</tr>
</tbody>
</table>
The proper pile length from the resisting surface is obtained from the intersection of the curve for allowable soil resistance with a straight line drawn from $M_x$ to $H_x$.

The values of embedment obtained from these graphs are from the resisting surface, and not from the ground line. To obtain the actual foundation depth, increase "L" by 1 or 2.

**Example:** (shown by dash line)

$M_x = 49$ ft. kips

$H_x = 0.8$ kips.

Allowable Soil Resistance $= 200$ psf/ft.

**Rigid:**

$L'' = 18$ Embedment

Then:

Total foundation depth $= 20'$. 
### Table 1197-11. Allowable Lateral Soil Resistance

<table>
<thead>
<tr>
<th>Tower Height (Feet)</th>
<th>Foundation Diameter (Feet)</th>
<th>Allowable Lateral Soil Resistance (psf/ft. of depth)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>100</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Foundation Depth (Feet)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>15</td>
</tr>
<tr>
<td></td>
<td></td>
<td>15</td>
</tr>
<tr>
<td></td>
<td></td>
<td>20</td>
</tr>
<tr>
<td></td>
<td></td>
<td>20</td>
</tr>
<tr>
<td></td>
<td></td>
<td>25</td>
</tr>
<tr>
<td></td>
<td></td>
<td>25</td>
</tr>
<tr>
<td></td>
<td></td>
<td>30</td>
</tr>
<tr>
<td></td>
<td></td>
<td>30</td>
</tr>
<tr>
<td></td>
<td></td>
<td>35</td>
</tr>
<tr>
<td></td>
<td></td>
<td>35</td>
</tr>
</tbody>
</table>

### Table 1197-12. Highway Lighting Responsibilities

<table>
<thead>
<tr>
<th>Facility</th>
<th>Area Unincorporated</th>
<th>Area Incorporated</th>
</tr>
</thead>
<tbody>
<tr>
<td>Interstate¹</td>
<td>State</td>
<td>State</td>
</tr>
<tr>
<td>U.S. Route¹</td>
<td>State</td>
<td>Municipal Corporation²</td>
</tr>
<tr>
<td>State Route¹</td>
<td>State</td>
<td>Municipal Corporation²</td>
</tr>
<tr>
<td>County Road</td>
<td>County</td>
<td>Not applicable</td>
</tr>
<tr>
<td>Township Road</td>
<td>Township</td>
<td>Not applicable</td>
</tr>
<tr>
<td>Public Street</td>
<td>Not applicable</td>
<td>Municipal Corporation</td>
</tr>
<tr>
<td>Private Street</td>
<td>Street Owner</td>
<td>Street Owner</td>
</tr>
</tbody>
</table>

Notes:

1. Where the facility is of freeway design, only the mainline and ramps are considered to be part of the facility.

2. The highway lighting maintenance and energy costs shall be borne by the municipal corporation.
1198 FIGURES INDEX

1198-1 Roadway Lighting Fixture Distribution

As noted in Section 1140-3.1, Figure 1198-1 illustrates five basic distributions of highway lighting fixtures.

1198-2 Effects of Full Cut-Off and Non Cut-Off Luminaires

As noted in Section 1140-3.1, Figure 1198-2 illustrates the effects of full cut-off and non cut-off luminaires.

1198-3 Typical Luminaire Placement Partial Interchange Lighting (PIL)

As noted in Section 1140-4.4.1, Figure 1198-3 illustrates typical luminaire placement for a partial interchange.

1198-4 Detail of Luminaire Placement for Class I Exit Terminal (PIL)

As noted in Section 1140-4.4.1 and Figure 1198-3, Figure 1198-4 illustrates detail information regarding luminaire placement for an exit ramp terminal.

1198-5 Partial Lighting Applications to the Basic Diamond Interchange

As noted in Section 1140-4.4.2, Figure 1198-5 illustrates typical luminaire placement for a basic diamond interchange.

1198-6 Reserved for Future Information

Figure deleted but the space has been saved for now.

1198-7 Intersection Lighting Examples

As noted in Section 1140-4.4.4, Figure 1198-7 illustrates typical luminaire placement for intersections.

1198-8 Luminaire Mounting Arrangements

As noted in Section 1140-4.5.2, Figure 1198-8 illustrates different luminaire arrangements for street lighting.

1198-9 Overpass Key Unit Locations

As noted in Section 1140-4.6.3, Figure 1198-9 illustrates overpass key unit locations.

1198-10 Underpass Key Unit Locations

As noted in Section 1140-4.6.7, Figure 1198-10 illustrates underpass key unit locations.

1198-11 Control Center Data Chart

As noted in Sections 1140-5.3.2 and 1140-3.8, Figure 1198-11 illustrates a chart used in the plans to provide information needed about the control center.

1198-12 Voltage Drop Study

As noted in Section 1140-5.2.2, Figure 1198-12 illustrates calculation and analysis methods for producing lighting designs.
Intentionally blank.
Figure 1198-1. Roadway Lighting Fixture Distribution

- **TYPE I**
- **TYPE II**
- **TYPE III**
- **TYPE IV**
- **TYPE V**
Figure 1198-2. Effects of Full Cut-Off and Non Cut-Off Luminaires

Full Cut-Off Luminaire (Plane Glass Lens) vs. Non Cut-Off Luminaire (Dropped Refractor)
Figure 1198-3. Typical Luminaire Placement Partial Interchange Lighting (PIL)

Notes:
1. For additional details of sketch (A), see Figure 1198-4.
2. (F) denotes additional unit, when future/full lighting is provided.
3. Unit spacing varies with pavement width.
4. Number of units depends upon the length of the speed-change lane.
Figure 1198-4. Detail of Luminaire Placement for Class I Exit Terminal (PIL)

* This spacing may be less on a sharply curved ramp, or when the design uniformity exceeds 4.0 to 1.0.

Notes:

1. This layout is based on an average initial intensity of 1.2 foot candles and a maximum uniformity of 4.0 to 1.0.
2. (F) denotes additional unit when future/full lighting is provided.
Figure 1198-5. Partial Lighting Applications to the Basic Diamond Interchange
Figure 1198-6. Reserved for Future Information

Figure has been deleted; however, for now the space has been saved for a future revision.
Luminaire mounting arrangements: (a) Median; (b) Right-side; (c) Left-side; (d) Staggered; and (e) Opposite.
Figure 1198-10. Underpass Key Unit Locations
Notes:

1. See NEC 230 Part IV for requirements related to service-entrance conductors. 230.42 (2011) has specific requirements on conductor size; in general, ampacity shall be a minimum of 125% of the continuous lighting load of the control center. Note that $125\% = 1/0.8$.

2. Refers to the ampere rating of the disconnect as specified by the manufacturer. NEC Art. 225 requires the Rating of Disconnect to be not less than the calculated load. Consideration should be made of future expansion of the lighting system, but at a minimum the rating shall be equal to the ampacity of the service-entrance conductors. The Short-Circuit Current Rating (SCCR) should be calculated using the power service equipment as provided by the power company. It is the Contractor’s responsibility to assure enclosure SCCR compatibility per NEC Art. 110.

3. Nominal fuse size should be a minimum of 125% of the calculated load, up to a value equal to the ampacity of the wire protected by the fuse. Standard ampere readings for fuses are given in NEC Art. 240. When the circuit fuse in the chart above supplies only a single lighting branch circuit breaker, the designer should specify a nominal fuse value at least two standard ampere ratings higher than the 125% value. Note that $125\% = 1/0.8$. 

<table>
<thead>
<tr>
<th>CONTROL CENTER DESIGNATION</th>
<th>POWER SERVICE VOLTAGE</th>
<th>CONTROL CENTER TOTAL CONNECTED LOAD (kVA)</th>
<th>SERVICE ENTRANCE CONDUCTOR SIZE (AWG)</th>
<th>ENCLOSURE RATING (AMPS)</th>
<th>FEEDER CIRCUIT CONNECTED LOAD (AMPS)</th>
<th>FEEDER CIRCUIT FUSE SIZE (AMPS)</th>
<th>BRANCH CIRCUIT NO.</th>
<th>BRANCH CIRCUIT LOAD (AMPS)</th>
<th>BRANCH CIRCUIT BREAKER SIZE (AMPS)</th>
<th>BRANCH CIRCUIT CABLE SIZE</th>
<th>MAINTAINING AGENCY</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
1. Voltage drop on circuit not to exceed 5% nominal circuit voltage in steady state since equipment can generally tolerate a voltage variance of 10%.

Because of the small wire sizes involved and the high power factor of the lighting load, the reactance is considered to be negligible in this computation. (AIEE publication No. 952 dated October, 1956)

2. Operating current for typical luminaires in ODOT HPS Highway Lighting Systems:

   Line Amperes Operating = (Lamp watt + Ballast watts)/Line voltage

   Ballast watts may be as much as 30% lamp watts for tertiary winding ballast.

<table>
<thead>
<tr>
<th>Lamp Wattage</th>
<th>Line Amps. Operating</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>480 Volts</td>
</tr>
<tr>
<td>100</td>
<td>0.27</td>
</tr>
<tr>
<td>150</td>
<td>0.41</td>
</tr>
<tr>
<td>200</td>
<td>0.54</td>
</tr>
<tr>
<td>250</td>
<td>0.68</td>
</tr>
<tr>
<td>310</td>
<td>0.84</td>
</tr>
<tr>
<td>400</td>
<td>1.1</td>
</tr>
<tr>
<td>1000</td>
<td>2.7</td>
</tr>
</tbody>
</table>

3. Obtain wire resistance from published data (engineering handbooks, manufacturers’ data sheets, etc. The following values are taken from NEC (2011) Chapter 9, Table 9:

<table>
<thead>
<tr>
<th>Wire Size</th>
<th>Ohms per 1000 feet</th>
</tr>
</thead>
<tbody>
<tr>
<td>14</td>
<td>3.1</td>
</tr>
<tr>
<td>12</td>
<td>2.0</td>
</tr>
<tr>
<td>10</td>
<td>1.2</td>
</tr>
<tr>
<td>8</td>
<td>0.78</td>
</tr>
<tr>
<td>6</td>
<td>0.49</td>
</tr>
<tr>
<td>4</td>
<td>0.31</td>
</tr>
<tr>
<td>2</td>
<td>0.19</td>
</tr>
<tr>
<td>1/0</td>
<td>0.12</td>
</tr>
<tr>
<td>2/0</td>
<td>0.10</td>
</tr>
<tr>
<td>4/0</td>
<td>0.079</td>
</tr>
</tbody>
</table>

4. Voltage drop in a Lighting Circuit Section = Amperes in and beyond the Section x [(Length of the Section in feet x 2 wires)/1000] x Resistance wire per 1000.

   Include in length of a section an allowance for connection at each end and slack. Frequently this is done by allowing 5-10 feet at each end and rounding up section lengths in increments of 5 feet.

5. To simplify calculations (see Figure 1198-12c): Lighting unit lead and voltage drop is computed only to the base of the support; underpass lighting load and voltage drop is computed only to the disconnect switch; and the sign lighting load and voltage drop are computed only to point of connection to the lighting circuit.
Figure 1198-12b. Voltage Drop Study – Sample Circuit Layout

LEGEND

LIGHT TOWER
CONVENTIONAL LUMINAIRE
WALL MOUNTED UNDERPASS LUMINAIRE
CANTILEVER SUPPORT WITH ILLUMINATED SIGN
SPAN SUPPORT WITH ILLUMINATED SIGN
PULL BOX OR JUNCTION BOX
POWER SERVICE
CIRCUIT

ALPHA POWER SERVICE "A"

CONTROL CENTER
POLE NO.
LIGHT NO.
SIGN NO.
WATTS
SIGN NO.
WATTS
PULL BOX NO.
PULL BOX NO.

3/0 94
24

200ft
200ft
200ft
400ft
50ft
DS-UP
500ft
AB-7
8 - 400 WATT LUMINARIES
PB-AB1
PB-AB2
PB-AB3
PB-AB4
PB-AB5
PB-AB6

200ft
200ft
200ft
200ft
200ft
200ft
200ft
200ft

Power Service "A"
Figure 1198-12c. Voltage Drop Study – Sample Voltage Drop Calculation

Co. FRA Rte. 99 Sec. 1.23 Sheet 1 of 1 Sheets
Power Service “A” Circuit B No. of Wires for Calculation Purposes: 2
Supply Voltage: 240/480 3-wire GND NEU
Wire Resistance Used: No. 4 AWG 0.2582
No. _ AWG.

<table>
<thead>
<tr>
<th>SECTION (1)(2)</th>
<th>AMPERES</th>
<th>AWG</th>
<th>VOLTAGE DROP</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>From</td>
<td>To</td>
<td>Feet</td>
</tr>
<tr>
<td>AB1</td>
<td>AB-2</td>
<td>200</td>
<td>0.84</td>
</tr>
<tr>
<td>AB2</td>
<td>AB-3</td>
<td>200</td>
<td>0.84</td>
</tr>
<tr>
<td>AB3</td>
<td>PB-AB1</td>
<td>400</td>
<td>0.84</td>
</tr>
<tr>
<td>DS-UP³</td>
<td>PB-AB1</td>
<td>50</td>
<td>0.81</td>
</tr>
<tr>
<td>PB-AB1</td>
<td>AB-7</td>
<td>150</td>
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</tr>
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<td>PB-AB2</td>
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</tr>
<tr>
<td>AB-4</td>
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</tr>
<tr>
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<tr>
<td>AB-6</td>
<td>PB-AB5</td>
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<tr>
<td>PB-AB5⁵</td>
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<tr>
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<tr>
<td>AB-9</td>
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</tr>
<tr>
<td>AB-10</td>
<td>PB-AB6</td>
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<tr>
<td>PB-AB6</td>
<td>AB-10</td>
<td>240</td>
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</tr>
</tbody>
</table>

1. To avoid repetition, the power service designation “A” is omitted in the point designation.
2. Lighting unit lead and voltage drop is computed only to base of support to simplify calculation.
3. Underpass lighting load and voltage drop is computed only to disconnect to simplify calculation.
4. Sign lighting load and voltage drop are computed only to the point of connection to lighting circuit to simplify calculation.
5. These columns are normally only computed for the point of maximum voltage drop.