Association of Outdoor Lighting Professionals

Landscape Lighting Guidelines

March 2012 v1.0

Low Voltage Landscape Lighting Systems

Table of Contents

Acknowledgements

These "Guidelines" were written, defined, and organized in 2011 by:

Mark Carlson, Chairperson of the AOLP Design Committee and Avalon Lighting Design

Additional modifications, enhancements and reviews were performed in 2012 by:

Brooke Perin, Chairperson of the AOLP CLVLT Committee and Wolf Creek Company
Gerry DeLaVega, Chairperson of the AOLP UL Committee and TerraDek Lighting
Mike Gambino of Gambino Landscape Lighting
Nick Shriver of Decorating Elves Lighting

The original works, called the "Standards for the Installation of Low Voltage Landscape and Architectural Lighting Systems" (established 2002) were developed by several key individuals, as members of the Low Voltage Lighting Institute of the Americas (LVLIA) in 2000. The LVLIA had an organization name change in 2009 to the Association of Outdoor Lighting Professionals (AOLP). These original members deserve credit:

Mike Gambino, Frank DiMarco, William Peterson, Heinrich Fischer, Todd Hedman, and Rick Baird

Disclaimer

The Association of Outdoor Lighting Professionals, hereinafter referred to as the "AOLP," approved this documentation to be utilized within the landscape lighting industry and specifically for the low voltage lighting trade. These Guidelines shall not supersede any regulation found within the National Electrical Code (NEC) or any other governmental agency, local code, or ordinance. All contractors and designers specifying this trade discipline should further research and understand the necessary codes and regulations for their specific regions.

Additionally, it should be recognized that the purpose and intent of Underwriter's Laboratory (UL) differs from that of the National Fire Protection Agency (NFPA), authors of the National Electrical Code (NEC). They have different objectives. UL is responsible for overseeing the safety aspects of the *production* of equipment through the use of Standards, whereas the NEC is utilized to govern or regulate via Standards, the use or *installation* of this equipment. Together, both UL listings and the NEC exist to protect the consumer and the contractor.

Content Scripting

The following content descriptions will show two forms of scripting: 1) standard font = "Specification", and 2) *italic font* = Informational description and background of the section.

Section A: General

A.1 Landscape Lighting Description

For the purpose of this document, the term "Low Voltage Landscape Lighting System," whether intended for landscape or architectural use, shall be considered as permanently installed landscape lighting systems. This includes the use of transformers, fixtures (luminaires) and cabling for the purpose of illuminating landscape environments and the exterior of structures or buildings.

A.2 Purpose of Guidelines

The AOLP has adopted this set of Guidelines for use with low voltage landscape lighting system installation practices. These Guidelines should be utilized by both the contractor and the consumer as a means for understanding what is expected with the installation of these lighting systems. Additionally, they will serve to improve quality practices, professionalism within the trade, and specific understanding between all parties.

Section B: Lighting Designs and Agreements

B.1 Lighting Designs

The AOLP recommends that all contractors prepare a landscape lighting plan in addition to their written agreements. There are currently no guidelines or standards in place to encompass the design component of this profession. Currently, the AOLP is the only organization to offer a Certified Outdoor Lighting Designer (COLD) program that addresses this aspect of landscape lighting design.

Landscape lighting designs should be in the form of a Conceptual Lighting Plan or a Detailed Lighting Plan. The purpose of these plans is to effectively communicate the what, where, when, and who is to install the lighting system(s), to all necessary parties. These designs should define the following minimum criteria:

- Equipment quantities—transformers, fixtures, control devices, and mounting devices
- Equipment placement or locations
- Power source type & locations—electrical panels, receptacles, junction boxes, switches, etc.
- Structures and/or hardscape elements—to be utilized in lighting applications
- Conduit & sleeve locations
- Tree & focal point locations—identification for use in lighting applications
- Electrical loads—calculations for each electrical circuit and transformer

Landscape lighting plans should utilize supporting elements to aid the customer in understanding the proposed work. These elements might include any or all of the following: 1) night-time lighting photographs, 2) demo kits to temporarily mock-up the lighting on-site, 3) visitations to other job sites, and/or 4) computer applications that use lighting software.

B.2 Installation Agreements

Installation agreements are legally binding contracts between the contractor and the customer. These contract documents include the landscape lighting plan and any other written specifications. The AOLP requires its members to utilize some form of written agreement, as is common and appropriate in one's own state. These agreements seek to protect both parties.

The contractor should supply the customer with a written agreement that both parties shall mutually agree upon and both shall sign upon acceptance. The following list describes items that are expected to be included in all agreements per Contract Law and standard legal practices—consult an attorney for additional information:

- Description of the property where the work is to be performed
- Scope of work—general description of what is to be done, who is to do it, and how it will be performed
- Quantities of all materials used—transformers, fixtures, cable, controls, and other relevant information
- Total cost of work to be performed
- Start & finish dates
- General product specifications and warranty information

B.3 Change Orders and Additions

Change Orders or Additions are actions taking place after the agreement is in effect. Once these changes are agreed upon by both parties, then they become part of the original contract agreement and will affect the final job cost.

Change Orders or Additions should be clarified and put in writing prior to performing any work outside of the original contract agreement. All changes must be mutually accepted and agreeable to both parties and signed by the customer in advance of the work.

B.4 Maintenance Agreements

As part of the original Installation Agreement, the contractor and/or designer should define the actions to be taken with all future lighting service work. The AOLP expects its members to service their installed systems for an agreed upon period of time. Typically, the installation contractor will warrant the lighting system for a minimum period of one (1) year from date of installation. Upon completion of this term, the contractor should either continue servicing the lighting system, assist the customer in learning how to do it themselves or work with a third party (selected by the customer) that will perform these maintenance services.

Maintenance agreements serve to primarily describe the costs and frequency of service visits during a set period of time (per agreed upon fee schedule), but at a minimum, should include the following:

- Description of the property where the work is to be performed
- Scope of work—general description of what is to be done, who is to do it, how it will be performed, and what is included and not included in these services
- Frequency of service visits and general date ranges
- Associated costs for labor & materials
- Service agreement term or period and signatures by both parties

Section C: General Specifications

C.1 Codes, Ordinances, Regulations, and Permits

The contractor shall familiarize himself with the current NEC code and shall install all landscape lighting systems according to the regulations stated therein. If a State adheres to the NEC code, then that sets the minimum standard. State and local codes and/or regulations can only add to the requirements; they cannot reduce them. Codes for those residing in the U.S.A. shall adhere to the National Electrical Code (NEC), and for those residing in Canada, the Canadian Electrical Code (CEC) and Provincial Code apply. These rules and regulations should become part of the specifications for all landscape lighting system installations performed by an AOLP member.

If required, the contractor should obtain an electrical permit (see local code requirements) for the installation of the low voltage landscape lighting system(s). Additionally, the contractor shall obtain the necessary inspections to satisfy this work. The contractor shall familiarize himself with all relevant codes and what is applicable by law.

The contractor agrees to adhere to all national, state, municipal and local rules or regulations pertaining to any portion of the landscape lighting installation.

C.2 Utilities

The contractor should acquire the service of his local utility marking company or “Dig Alert” to identify all locations within the work zone that contain utility runs.

The “Dig Alert” type service is typically free of charge and is required prior to commencing any excavation work. Failure to have this marking service completed can result in injury, property damage, fines and penalties if a utility line is hit during construction. Nationally, contractors can call “811” to initiate a ‘Call Before You Dig’ alert.

C.3 Protection of Customer’s Property

The contractor should maintain adequate protection or insurance coverage for any damages caused during the installation process. The installation contractor should make every effort to keep the customer’s property in good condition and to return it as best as possible to the original condition prior to leaving the installation site.

C.4 Job Site Safety & Safety Procedures

Job site safety must be considered at all times and above all else. Other than "Acts of God," **all accidents are preventable**. Each contractor, sub-contractor, and each employee on-site is responsible for checking the job site for safety-related issues prior to starting any work. Any unsafe working condition needs to be documented. Any unsafe tool or equipment needs to be reported, replaced and/or repaired. Job site workers are to be using all safety devices and equipment available to them to maintain a safe and friendly working environment.

All safety procedures are to comply with the Occupational Safety and Health Administration (OSHA) of the United States Department of Labor Standards for the Construction Industry. For a complete set of documents, such as the construction industry manual and other resources, please refer to **www.osha.gov**.

The AOLP has summarized and adopted elements of the OSHA Standards for the Construction Industry as "best practices" for job-site safety. It is imperative that our members follow and adopt these practices into their daily activities. As a landscape lighting contractor/designer, it is your primary goal to perform all work in the safest manner possible that is in compliance with these standards.

There are five (5) procedures to follow **prior to starting any job**, which will aid in the prevention of job-related injuries:

- Identify who is responsible for the entire job and who is responsible for each trade on-site
- Visually assess the job site and identify all hazards present (if possible). Properly mark and report these hazards to those in-charge or responsible for employees
- Communicate or identify any tools, equipment or other trade employees that are presenting a danger to those in-charge or responsible for employees
- Remove or repair all hazardous conditions and/or exposure to illness or injury
- Maintain awareness at all times to ensure a safe working environment

It is the responsibility of the contractor/employer to initiate and maintain accident prevention responsibilities. Such programs shall provide for frequent and regular inspection of the job site, materials, and equipment. This inspection needs to be performed by a competent person and covers the following (**OSHA 1926.20**):

- Safe working environment—clean and free of debris
- First-aid kit placed in a weatherproof container, easily accessible and checked regularly (**OSHA 1926.50**)
- Sanitation and adequate supply of potable water in all places of employment (**OSHA 1926.51**)
- Proper illumination of working area (**OSHA 1926.56**)
- Personal protective and lifesaving equipment—eyes, face, head & extremities, protective clothing, respiratory devices, and protective shields & barriers (**OSHA 1926.95 and 1926.107**)
- Fire protection and prevention (**OSHA 1926.150**)
- Proper signage, signals and barricades (**OSHA 1926.200**)
- Proper training of hand and power tools (**OSHA 1926.300**)
- Electrical equipment and installation of both temporary & permanent electrical works (**OSHA 1926.400**)
- Fall protection and safety (**OSHA 1926.500**)
- Excavation protection and safety (**OSHA 1926.650**)
- Stairways and ladders protection and safety (**OSHA 1926.1050**)

Prior to entering a job site, a "hazards analysis" or site review should be performed by the contractor. The following list shows the more common potential hazards that are easily identifiable. Hazards can be anywhere and they are not limited to the following:

- Buried utilities—should be identified by type and by local agency, such as "Dig Alert"
- High voltage devices and equipment
- Cluttered work areas
- Other contractor trades not practicing safety
- Other tradesmen's tools and equipment without safety devices
- Roadway traffic—proper safety cones and barricades in proper locations
- Parking conditions
- Possibility of slips due to wet or uneven surfaces
- Possibility of falls due to broken stairs, ladders, etc.
- Anything that can cause cuts and/or burns
- Exhaust fumes from tools or equipment, especially in unventilated areas

- Toxic or poisonous plant materials
- Venomous creatures or unfriendly animals
- Harsh or extreme weather conditions—sun & heat, snow/ice & cold, rain & mud
- Chemicals on site and flammable materials or conditions

The contractor should properly communicate the proper use and expectations of all safety devices available on the job site, to all employees:

- Eye and ear protection
- Hand and feet protection
- Head protection
- Hand tool and equipment use (to include proper training)
- Lifting techniques and procedures
- Ladder and scaffolding use (to include proper training)
- Open trenches
- Tree climbing techniques and procedures (to include proper training)
- Fire extinguisher use (to include proper training)
- Seat belt use in vehicles and equipment
- Reporting procedures for unsafe conditions & equipment (to include accidents or injuries when they occur)
- Clothing and jewelry wear
- Drug use
- Horseplay and any unacceptable behavior on site

C.5 Materials & Workmanship

To ensure a high level of professionalism, the AOLP would expect its members to practice good workmanship and to utilize good quality materials on every job. This includes providing all necessary information about the job to the customer.

Upon job completion, the contractor should provide a list of the primary equipment used with their warranty information, to include transformers, fixtures, and controls.

All materials and equipment should be installed in a neat and workmanlike manner according to these Guidelines.

C.6 License, Bond, & Insurance

The contractor should provide to the customer, if requested, his/her contractor's license number, bond information, and proof of insurance(s), as required to perform this work.

The installation contractor of the landscape lighting system, as required by law per individual state or country, must show proof of his license and any bonding requirements and is responsible for the minimum amounts of insurance coverage.

C.7 Warranties

The AOLP recommends that each member company warrants its landscape lighting system installation and workmanship for a minimum of one (1) year from the completion of the project.

Warranties on materials should include the following information: 1) Manufacturer's name & contact information, 2) Model number and name, and 3) Warranty period from manufacturer and associated terms & conditions.

No warranty is given by incandescent or halogen lamp (bulb) manufacturers. This is considered acceptable in the lighting industry, due to the sensitivity and the burn cycle of each lamp filament. LED components will have their own set of warranties—see individual manufacturer information.

C.8 As-Built Records

The AOLP recommends that its members prepare an As-Built Plan for the installed lighting system. This process and practice is common in the architectural field. There are several reasons for preserving this information: 1) legal representation of what was installed, 2) record of all final locations and quantities that will aid in future service and/or system expansion, and 3) record of all final electrical loads.

As-Built plans should include enough information to locate all equipment used in the installation of the landscape lighting system. They should identify power sources, transformers, fixtures, lamps, cable runs, hubs or junction points, conduit or sleeves, accessory items, and control devices.

As-Built information should be kept by the installation contractor for a minimum of three (3) years. Once this period has expired, then the contractor should ensure that the customer and/or the maintenance service provider, has a copy of these documents.

C.9 Installation Records

As with the As-Built records, the AOLP requires the installation contractor to keep all documents pertaining to its installation work for no less than three (3) years. Installation records help to identify what and where the equipment is located on the job site, and includes notes on anything pertaining to the installation process.

Installation records should be kept by the installation contractor for a minimum of three (3) years and should include the following information:

Power sources (120-volt):

- Electrical panel & sub-panel locations, to include the breakers used (size & location number)
- Electrical receptacles (outlets) and if they are GFCI protected

Transformers:

- Location, size, load, and incoming voltage (120-volt)
- Brand, model number, date of installation, and who installed it

Cable runs:

- Routes of travel and zones covered
- Wire size, primary or home-run total wattage, fixtures supplied, and color code/number for each run
- Wire size for all secondary runs to each fixture

Fixtures:

- Quantity of each type of fixture, brand, accessories and mounting attachment
- Quantity of lamp sources: type, wattage, beam spread, and color temperature
- Location of each fixture type

Conduit/sleeves:

- Location of each sleeve, size of conduit and type
- What is included in that conduit (if additional wiring from others)
- Note: 120V and 12V may NOT be installed in the same conduit

Controls:

- Type of device used at each transformer, brand, model number, and device location (inside/outside of transformer)
- Control system codes, if applicable
- Who installed and/or programmed controls

Special notes:

- Anything not covered in these records that is pertinent to the operation of the system

Section D: Materials and Equipment

Materials and equipment selection is left to the contractor to decide, as he/she should know what is best for the project based upon experience, customer budget, and job requirements. The policy of the AOLP is to <u>NOT</u> recommend any particular product manufacturer. However, members should use quality products from reputable manufacturers.

D.1 Materials Selection

There are several criteria that should be considered in the selection of materials. The AOLP recommends that the contractor and/or designer evaluates the following: 1) product warranty, 2) manufacturer's experience and longevity in the market, 3) quality of components used within each product type, 4) performance testing on these products, 5) feedback from other experienced installation contractors, and 6) industry safety listings or ratings.

The AOLP has provided this set of Guidelines as a means for its members to set themselves apart from other contractors and designers not following good practices. Additionally, the AOLP expects its members to be professional in all of their choices by using quality materials from reputable sources. Please take the time to investigate your sources for products and services, and to ensure that they meet the expectations set forth in these Guidelines.

The installation contractor should only utilize products that are "listed" (per Underwriter's Laboratory) for their intended use as per NEC code. This requirement is in place to ensure the safety of the consumer, as all "listed" products have been properly tested by a certified testing facility. There are several certified testing facilities that provide these services--Underwriters Laboratory (UL), Electrical Testing Laboratory (ETL), Canadian Standards Association (CSA), and others.

The current "listing" that governs all manufacturers of any landscape lighting system components is **UL 1838**. This listing covers and applies to a complete outdoor lighting system—all sub-components are considered part of the "system."

D.2 Transformers

The transformer is the heart of a low voltage lighting system, and it controls the distribution of power to the individual light fixtures. Transformers must be "listed" (having been tested by a certified testing facility) for their intended use. A transformer is basically a 'converter' that allows the incoming line voltage (120-volts) that is present on the primary side to be converted down to low voltage (12-volts) on the secondary side.

Transformers can be manufactured to allow for single-voltage output (single-tap) or multi-voltage outputs (multi-tap). The majority of contractor-grade transformers are multi-tap units.

Low voltage transformers that are "listed" under **UL 1838** are limited to 15-volts maximum and 25-amps maximum on the secondary low voltage output side.

Low voltage transformers that are acceptable to use, but are NOT "listed" under **UL 1838**, are those that contain voltage taps above 15-volts and up to 30-volts maximum. These transformers are "listed" under **UL 506** and are considered to be "general purpose" transformers. These transformers are NOT recommended for use by those who have not been properly trained to manage this voltage output.

Low voltage transformers that supply power to any underwater fixture located in a water feature (non-human use) or a non-pool application must be specifically rated for **submersible use**.

D.3 Cable

Low voltage electrical cable supplies the electricity necessary to energize the light source or lamp within the light fixture. There are standards that govern many aspects of cable production, but differences do exist between manufacturers (e.g., the use of a virgin material vs. a regrind or recycled material, etc.).

The following cable specifications should be used for all low voltage lighting installations. Cable or underground, low energy circuit cable (SPT style) construction consists of stranded, uncoated annealed copper conductors, laid parallel and insulated with a polyvinyl chloride (PVC) jacket. All cable used in landscape lighting applications must be listed for direct burial by UL, ETL, or CSA.

The insulation, jacket, or sheathing of a cable must conform to **UL Class 43**—made of black PVC, rated at 60-degrees Celsius, thermoplastic, 150-volts maximum, and suitable for direct-burial applications. One leg has "raised ridges" and the other leg is "plain" and shows identification markings that are either ink printed or indented into the PVC jacket. This marking should show the following: 1) cable manufacturer, 2) size rating (AWG), 3) description of cable, as "underground low energy circuit cable, sunlight resistant for outdoor lighting", and 4) "listing" file number.

Cable construction should comply with the following specifications:

Size (AWG)	# of Strands	Diam. of Strands	Insulation Thickness (Mils)	Max. Rating (A)	Max. Rating (W)	80% Load (W)
18	41	.0063"	45	10	120	96
16	26	.0100"	45	13	156	125
14	41	.0100"	45	15	180	144
12	65	.0100"	45	20	240	192
10	104	.0100"	45	30	360	288
8	133	.0111"	60	40	480	384

D.4 Fixtures

*Lighting fixtures are called "luminaires"—they protect and house the lamp source. Each fixture design can vary greatly and it is up to the contractor to select fixtures based on the following: 1) construction materials, 2) component options, 3) tooling tolerances, 4) strength & durability, 5) mounting options, 6) color finishes, 7) warranty, and 8) cost. All fixtures should be subjected to the performance tests established under **UL 1838.** This testing is completed by the manufacturer.*

The contractor or designer should verify that all light fixtures are **UL 1838** listed before specifying them.

D.5 Wire Connectors

*Wire connections are the most important part of the installation process and these connections are critical to the success and performance of any lighting system. Great care should be taken when joining wires together to ensure a strong and proper connection. Poor wire connections are frequently the weakest link to any electrical circuit. It is critical that all connections are waterproof to ensure their performance over the long term. There are a wide variety of connectors available in the market, so it is essential to select products that are properly specified for the intended use. This will ensure that they are secure and durable so long as they are installed per the manufacturer's instructions. The AOLP recommends using connectors that are mechanical in nature and comply with an appropriate UL listing for intended use. The most robust UL listing for direct-bury connectors is currently **UL 486D**. While not promoting one product over another, some of the better connectors involve heat shrink tubing over a barrel connector, soldered connections, lug nuts with grease caps, silicone-filled/twist-on wire nuts with a zip tie on the wire to provide strain relief, some two-piece connectors, wire nuts with grease tubes, etc.*

All wire connectors should be strong, secure, and reliable. They should be physically tested by the contractor, by pulling on the individual wires to ensure that they remain intact and secure inside the specified connector. Acceptable forms of connectors are mechanical lugs, wire nuts, butt splices, crimp connectors, and solder welds.

All wire connectors used in an outdoor environment should be waterproof and listed for this purpose. These cables and connections should be sealed so as NOT to allow any water intrusion within the cable jacket/sheathing. Acceptable forms of waterproofing are: 1) epoxy resins, 2) coated heat-shrink tubing, and 3) industrial-grade, 100% silicone encapsulated connections.

D.6 Hardware

The term "hardware" is used to describe material components that are associated with the installation of landscape lighting equipment. This includes components of the power establishment, transformers, fixtures, mounting devices, etc.

The contractor should utilize hardware components that are specifically designed to withstand the extremes of any exterior environment, such as stainless steel or any other suitable non-corrosive material deemed appropriate for the area in which it is being installed.

D.7 Conduit & Sleeves

Conduit should be utilized for the protection of cable runs that are exposed to potential damage. This type of protection is also called "sleeving." Applications for such use are under hardscape areas, such as concrete or driveways, and might include areas that are prone to greater service frequency, such as flower beds or turf areas. Additionally, conduit should be used in above-grade applications where cable exposure is unsightly or has a potential for damage such as wire runs up into trees or structures and even into the transformer housing.

Conduit used for exterior applications should be resistant to damage, whether from chemical re-action or UV exposure. The contractor should decide which type of conduit is best suited for the situation or environment it is

to be placed. Electrical conduit should be grey in color. If polyvinylchloride (PVC) pipe is used, then it must have a minimum rating of Schedule 40.

Drain pipe can be used for sleeving purposes only if it has enough strength to avoid crushing or breaking under normal soil loads. Never use polyethylene tubing (standard drip tubing), as this will not prevent damage to the cabling.

Section E: Installation Procedures

The following installation procedures have been adopted by the AOLP for use by its members and those looking to better themselves in this specialty trade. These Guidelines are considered to be the minimum requirements for anyone installing landscape lighting systems.

The overall governing document that supersedes these Guidelines is the National Electrical Code (NEC)--it should be reviewed at least every two years upon release of NFPA revisions. It is recommended that the installation contractor should verify all site conditions and all power source needs prior to starting any work.

E.1 Power

The power provided to all landscape lighting systems covered in these Guidelines is considered to be 120-volt.

All 120-volt electrical work should be performed by a licensed electrician unless otherwise specified by law. Refer to all NEC and all local codes for additional details.

If possible, power should be centrally located and established within each lighting zone. Also, it is recommended to utilize a dedicated electrical circuit to power the outdoor landscape lighting system.

All exterior receptacle boxes should be G.F.C.I.-protected for use with transformers that utilize a plug-in cord. Do NOT cut off the plug end of the transformer power cord in order to hard-wire the unit into the 120-volt supply, as this will negate its UL listing. However, some localities allow for this hard-wiring method. Refer to all NEC and local codes. Confirm with the manufacturer prior to cutting the plug end off of a transformer because doing so could negate the transformer's warranty.

All receptacle boxes should utilize an "in-use" or "bubble" type receptacle cover to protect it from water entry.

All receptacles should NOT be located within 20-feet of the electrical panel or the circuit breaker, as this will help to avoid nuisance tripping of that circuit's breaker. This can occur with transformers during their initial start up and incurs an in-rush, overload current through the breaker.

All receptacles, low voltage transformers, and fixtures CANNOT be located within 10 feet of any water source that would be normally occupied by humans. Refer to **NEC 411.4(2)**.

E.2 Transformers

All transformers should be sized to allow for any future increase in system load, as well as the resistive values associated with longer cable run distances and the use of voltage taps greater than 12-volt. Typically, the limit should be set at 80% of the transformers full capacity. Transformers installed in exterior applications should be rated for use in "wet" locations. These power units should be installed in accordance with all NEC and local codes—failure to do so will void the warranty and may result in serious injury and/or damage to the transformer. Use caution when servicing transformers and if needed, disconnect the unit from the 120-volt power.

All secondary circuits must NOT exceed the limit of 300-watts or 25-amps per 300-watt core. A cable run should NOT exceed 80% of its rated capacity for the wire gauge size used. When working with multi-core transformers, the loads should be balanced between each 300-watt circuit.

Above-grade transformers, when installed outside, must be mounted a minimum of 12-inches above grade and within the cord's reach of the receptacle box. Installation of a protective conduit should be utilized between the

finish grade and the transformer wiring compartment. If the transformer area is subject to snow accumulation or flooding, then it is recommended to mount the unit higher to avoid submersion of the transformer in water.

Transformer mounting should follow all manufacturer recommended procedures. The contractor should use all available mounting slots to secure the unit's weight on to any structure. Care should be taken to understand the best practice to use when securing to any of the following materials: stucco, wood, metal, or masonry. Transformers can be post-mounted, but care should be given to the solidity of this method, the use of treated lumber is required and a concrete footing may be necessary.

When using a transformer power cord, it should utilize a "drip-loop" before the 3-pronged plug end enters the receptacle cover. The cord should fall below the level of the receptacle outlet to prevent water from traveling down the cord and entering the receptacle box.

Do NOT locate a transformer within a completely enclosed or confined space. There is little to no airflow in these areas—transformers must be well ventilated.

All secondary cable runs entering the transformer wiring cavity should be identified by colored tape or zip ties or a numbering label system. Ample slack should be allowed within the wiring cavity and just below the transformer as it enters the soil—this will aid in future service work.

In-grade transformers (also called "subterranean" or "direct bury" units) must be listed for their intended use. They should NOT be located in low lying areas where water can pool up or in high-traffic routes.

Excavation of the transformer pit should allow for a clearance around each side and underneath the unit for a gravel sump—at least 6 inch clearance around each side and below for the gravel sump base. Some prefer to use a large in-grade irrigation valve box that has a removable lid where the in-grade transformer can be placed inside—this allows for an easier and cleaner method of access to the unit.

The gravel drainage pit should provide for proper drainage by using a perforated drain pipe that is extended beyond the gravel sump at a 30-degree angle, at the lowest slope of the land.

All primary (120-volt) wiring and secondary wiring (12-volt) should be brought into the transformer housing and labeled for identification. Primary leads should be 12-inches minimum and secondary leads should be 24-inches minimum.

All in-grade transformer fittings should be tightened properly to secure wiring in place and to ensure water-tight applications. All conduit feeds into the housing must use plumber's putty to seal wires within the potting wells as it is important to seal each well prior to adding the re-enterable epoxy or sealing permanently with wax. This will ensure that these entrances are completely waterproof.

Waterproofing or potting transformer housing wells should utilize a re-enterable epoxy mixture that is approved for such use, such as "3M" #8882 or its equivalent.

E.3 Cable

When installing cable runs, it is recommended that the contractor include extra cable length with all runs to allow for adjustments, repairs and slight lighting system expansion (if the transformer capacity permits).

The load placed on low voltage lighting cable should NOT exceed 80% of its rated capacity—see cable chart shown in **Section D.3, Cable** for reference.

Cable runs used in direct-burial applications should be buried and/or secured in place to a minimum depth of 6-inches. NO cable should be left exposed on the surface of the landscape. Cable runs should follow "hardscape" elements, such as concrete edges, fences, walls, etc., to better ensure their protection. Extra cable length should be allowed for and bundled up at key points along each run: 1) at the ends of sleeve crossings (12-inches minimum outside of each conduit end), 2) just below the transformer (12-inches minimum), and 3) at each fixture location (3-feet minimum).

NEC requires cable to be buried to a depth of 6-inches. However, cable in lawn or turf areas should be buried to a minimum depth of 8-inches to 12-inches, due to landscape maintenance work. It is best to NOT locate cables directly against concrete edging, mow curbs, and/or turf borders, as service personnel regularly perform "edging" work that may cause damage to materials placed below. It is advisable to use conduit in these areas for added protection.

Cable runs in annual or perennial beds should be placed in Schedule 40 or thicker conduit and buried a minimum of 6-inches in depth. These landscape areas require frequent work or seasonal changes and therefore make the cable more vulnerable to nicks and cuts.

Cable runs used in exterior, above-grade applications, such as in trees and/or structural elements, should be secured in such a manner that best applies to the structural element and with the proper hardware.

Use stainless steel fasteners on trees. NEVER use copper or brass screws because of their toxicity to the tree. Cable and fixtures should NOT be directly attached to the tree with staples or tie-wraps as they will be engulfed or bands will choke off the tree's cambium layer and block essential nutrient flow.

Cables need to be "off-set" from the tree trunk or branch and have a "stand-off" clearance of a minimum of 1/2-inch to 1-inch away from the tree exterior. A method of attachment should be used that will allow the cable to hang securely, yet freely, away from the tree.

Cables should be supported and attached to a tree with the use of a stainless steel screw and cable attachment device. A 3-inch to 4-inch screw should be driven into the outer bark and then the cable can be attached to the screw shaft with either a "C"-clamp or cinch-tie.

Cable runs should be located on the least visible side or back side of the tree to hide them from the primary viewing angles of the most viewers within the landscape. For tree mounted fixtures, it is best to run the wire along the side of the branch and not on top where squirrels or other rodents may chew at it if the cable is underfoot.

Cable runs into structures and other "hardscape" elements should be hidden from view and secured in place with the proper hardware. Cables can be placed inside of conduit, which will conceal them and protect them from damage. All hardware or metal components should NOT be allowed to discolor the structure when exposed to oxygen and water.

Conduit should be utilized for cable runs within all concrete or masonry applications. This will ensure the protection of the cable inside these permanent structures. "Hard pipe," such as Schedule 40 PVC, metal ENT, or copper pipe, and "flexible pipe" such as blue ENT ("smurf" tube) are typically used. The contractor should determine which conduit type to use, as it is dependent on aesthetics and construction application. All cable feeds should extend beyond or stub-out at each fixture location, a minimum of 12-inches.

Cable fed into or onto wood structures, such as patio covers, pergolas or trellises, should use construction methods that help to conceal these runs from any primary viewing angles. The contractor should use materials that are non-flammable or non-combustible to either conceal or to secure to the wooden structure.

Cable fed into metal structures should use construction methods that will allow access to the internal open spaces of these structures. Care should be taken as all metal ends or openings can have sharp edges—DO NOT cut or expose any internal wire strands within the cable sheathing. All cables must be free to move and have sufficient slack built into their runs. All cables attached to the exterior of the structure should be hidden from any primary viewing angles.

Cable runs into water features should be protected from any potential damage that would expose the wiring to the water. All cables should be rated and listed for such exposure. Typically, submersible fixtures come with a minimum of 20-feet of cable already attached that will allow connections to be made outside of the water—sometimes, custom cable lengths can be made by the manufacturer to allow for longer runs.

Cable runs in interior applications, where cable is fed into interior spaces or within permanent dwellings, such as homes, buildings, or other structures, must follow all NEC and local codes. These types of installations require special installation methods to prevent the risk of fire.

E.4 Wire Connections

The wire connection is the most important process performed in the installation of any lighting system. It is often the most over-looked step and it requires great care for a properly functioning system. There are four (4) steps to ensuring a good, solid connection: 1) stripping and removal of the outer protective insulation/jacket of the cable without the loss of any copper wire strands, 2) securing all wire strands within the connector or splice junction, 3) ensuring a tight and solid connection between all parts, and 4) waterproofing the connection and cable. Refer to ***Section D.5, Wire Connectors*** *for additional details on suggested materials.*

Poor or weak connections can cause severe and damaging results, such as electrical arcing between parts. This can cause the cable to melt due to overheating—this is a resistive type of condition that creates excessively high amperage flow and heat that is above the limitations and capability of the cable.

When stripping cable sheathing, be sure to keep the wire strands inside the jacket completely in-tact, as for every two strands that are cut away, depending on cable size (gauge), there will be a voltage loss potential of 1%-3% of its ability—that's between 0.1-volt to 0.4-volts lost.

Cable sheathing needs to be stripped away from the underlying wire strands in order to make a proper connection. The contractor should ensure that NO copper strands are cut away during this process.

Wire jacketing should be trimmed to the appropriate length recommended by the wire connector manufacturer. This will ensure that NO copper wire is exposed below the connector and that no excess cable sheathing is pushed up inside the connector. Each connection should be strong, tight, and secure.

All wire connections should be physically pulled on and inspected to ensure that they do not pull apart.

Connections made inside the transformer wiring compartment are generally at the terminal block. These lugs should be tightened securely to ensure that wiring does NOT pull free. If cable leads ("pig tails") of adequate size are used to connect several cable runs together inside the compartment, then the proper size connector should be used to maintain a proper connection. Contractors should ensure that all lugs not used in the terminal block are fully closed to prevent foreign objects/debris from entering and creating a dangerous electrical arc.

Wire nut connectors should be rated and listed for their intended use within these low voltage landscape lighting systems. It is important that when wire strands are joined together between cables that they should NOT be overly-twisted together, as this will compromise the quality and performance of the connection—over-twisting can result in the connector shearing off copper strands inside the wire connector. These connectors must be waterproof and prevent moisture and oxidation from occurring within the cable sheathing. There are a variety of waterproofing methods, and it is up to the contractor to decide which is best for the need at hand.

Connections made by twist-on wire nuts should utilize the proper size wire nut to ensure a strong connection and proper fit—see wire nut manufacturer specifications for number and size of wires allowable. Do NOT over-twist wiring together within the wire nut.

All connections that are exposed to the exterior environment should be waterproof to ensure the integrity of the lighting system.

E.5 Fixtures

All fixtures ("luminaires") must be listed for their appropriate use, as described in ***Section D.4.1, Fixtures.*** *The contractor needs to follow all manufacturer recommendations for the proper installation and use of a fixture, as well as identifying the maximum lamp wattage to be used. The voltage at each incandescent or halogen lamp should be tested so that its operating range is between 10.8- volts and 12.0- volts at all times. LEDs offer a broader voltage range.*

All light fixtures should be rated for their intended use and **UL 1838** listed. The installation contractor should follow all manufacturer recommendations for the proper installation and lamp or LED use.

E.5.1 Ground-mounted Fixtures

There are a wide variety of fixtures that are included in this category (up lights, wash lights, path lights, bollards, etc.), and they comprise the majority of light fixtures available in the market. These fixtures can be mounted by a ground stake or a post-mount type assembly. Ground stakes are normally made of a composite material that is non-reactive with the various soil types or they are made of metal (brass, copper, or steel). If metal stakes are use, then corrosion will be a concern. Once the fixture is located and the connection is made to the feeding cable, then the surrounding soils should be compacted around the stake or post--enough to secure it in a manner that is plumb and proper for adjustments. Excess cable should be buried and kept at each fixture location to allow for future plant growth and the necessity of moving fixtures during future service visits.

Stake-mounted or post/stem-mounted fixtures should be secure and should be installed with hardware of a proper size to support the overall fixture height and weight. The contractor should determine if the stake or post is stable enough for the soil type in which it is installed.

All ground-mounted fixtures should have an extra 3-feet to 5-feet of cable bundled and located at the base of each fixture.

Stakes should be either hammered into place or a hole can be excavated and the stake positioned appropriately. The soil surrounding the fixture should be compacted back in to the hole and around the stake so that the fixture stands firmly in place. Ensure that the fixture is set “plumb.”

Fixtures should be located out of the direct path of any sprinkler head, and they should be off-set from any pedestrian routes (paths, walks, patios, or drives).

Post-mounted fixtures may require a concrete sub-base to handle the added weight and height being supported at higher levels. In this instance a "post" is described as a length of pipe (typically composite) positioned vertically in the soil or a concrete sub-base, with several inches sticking out above ground. A minimum of 1/4 or 1/3 of the pipe should be below grade to ensure its stability. A cap is placed on top of the pipe. This cap has a threaded 1/2-inch hole in the top of it, and a fixture can be mounted accordingly.

E.5.2 In-grade Fixtures

In-grade fixtures or “sealed” well lights should be completely enclosed to prevent any water or debris from entering the lamp housing area. “Open-sleeve” well lights are not sealed and it is recommended to have some sort of glass lens or louvered grate installed to minimize debris entry into the sleeve area. It is important to prepare the fixture pit or hole, to allow water to drain away from the well light. The contractor needs to construct a gravel drainage sump and utilize an adjoining drain line away from this installation. Well lights can be installed directly into the soil or landscaping or they can be installed into a sleeve and used within the “hardscape” or concrete setting. Many manufacturers offer an accessory concrete pour kit for this purpose.

“Softscape” areas are those that are non-permanent in nature, such as turf or lawn, planters, etc. “Hardscape” areas are those that are permanent by nature, such as concrete, masonry, etc.

All in-grade fixtures or well lights should be located in soil conditions that allow for good drainage. When soil conditions are poor, the contractor should install a drainage pipe at the bottom of the fixture pit and within the gravel sump. This drain pipe should be set at a 30-degree angle from the lowest slope side to allow water to be carried away from this location.

Well lights that are installed in “softscape” areas should use a gravel drainage sump as a base to support the in-grade fixture. The top of the well light should be slightly higher than the surrounding grade to prevent water from settling in at the fixture.

All in-grade fixtures located in “softscape” areas should have an extra 3-feet to 5-feet of cable bundled and located at the base of each fixture or within the well light housing.

Excavation of the well light hole should be at least 3-inches wider and at least 6-inches deeper than the overall fixture dimensions. This hole should be clean of debris and loose earth. If necessary, prepare hole for drainage pipe addition.

Fill the well light hole or bottom of the gravel sump pit with a minimum of 6-inches of pea gravel. Locate and pre-position the well light assembly. Bundle up the extra cable and then add the remainder of the pea gravel to within 2-inches to 4-inches below the finish grade. This will secure the fixture in place.

Prepare and test the well light with its appropriate lamp or LED to ensure that it is operating properly. Contractor should refer to the manufacturer's installation requirements prior to completion of this work. Finish off the backfill with either pea gravel or the complimentary landscape materials removed during excavation (soil, lawn, mulch, decomposed granite, etc.) up to and under the edge of the well light face cover.

Final adjustments and aiming should be performed before finalizing any settings.

Well lights installed in "hardscape" areas should use an outer composite shell or "pour ring" during the initial set up of this in-grade fixture. These shells must be set in place prior to any concrete pour and the contractor will need to determine what elevation they are to be positioned at for any final grade needs. Conduit should be utilized and installed prior to the installation of any shell housings. All preliminary work should be done in advance of any concrete or masonry work.

All in-grade fixtures located in "hardscape" areas should have an extra 12-inches to 3-feet of cable bundled and located within the well light housing.

Conduit should stub-out or up into the housing a minimum of 2-inches. All exposed or open conduit ends should be protected from debris entry by taping them off or applying end caps.

Set all well light housings to their appropriate elevation, so that the fixture will set in at the finish grade elevation. The contractor should verify that these positions have not changed prior to any concrete pour.

Properly secure each well light or fixture housing by utilizing re-bar and wire ties or any other equivalent method, so that the fixture housing will NOT move during the concrete or masonry installation. It is recommended that the contractor oversee this work to prevent any damage from occurring.

Install a protective lid or cap to the open top end of the housing so that the interior space of the housing is protected from debris or concrete spillage. Duct tape can be utilized in place of a fabricated lid and this can be removed after the pour.

Upon completion of the concrete or masonry work, the contractor will need to remove the duct tape or lid and then trim off any extra length of the housing that might be exposed at the finished surface. Remove any excess debris from within the shell housing and prepare the well light for installation. Ensure that proper connections are made and that all connections are waterproof.

Install the correct lamp and ensure that it operates properly before setting the well light into final position. Secure the well light in place per the manufacturer's requirements and perform the final adjustments and aiming before finalizing these settings.

E.5.3 Above-grade Fixtures

Above-grade fixtures include those that are attached to structures and those that are attached to trees. Either way, it is important to hide the cable run(s) from the primary viewing angle. Refer to ***Section E.3.2, Wiring/Cable*** *for additional details.*

Fixtures attached to a structure should be mounted directly to its surface. Care should be taken to ensure that the proper aiming angle is maintained. Allow an extra 6-inches to 12-inches of cable at each fixture location for any future service work. Ensure that all connections are solid and waterproof.

Locate and attach the fixture in accordance with the manufacturer's recommendations. Ensure that this final placement is appropriate for hiding the fixture and to ensure proper aiming needs. The contractor should take care to avoid creating a glare spot from the primary viewing angle(s) as much as possible.

Cable attached to structures should be in conduit, directly attached by cable staples or clips, or by any other appropriate means to secure the cable safely to the structure. Care must be taken if attachment is to a combustible material. All attachment hardware should not stain or discolor the structure surface—stainless steel fasteners are recommended.

All cable access holes drilled into the structure should be sealed off with 100% exterior rated silicone.

The contractor should utilize good glare control techniques--glare shields, hex baffles/louvers, etc.

Fixtures attached to a tree should have stand-off clearance of at least 1/2-inch to 1-inch away from the tree to ensure that the tree does not grow into the attached fixture or its mounting hardware. Mounting hardware attached directly to the tree bark (without any prescribed stand-off clearance) will harm the tree by allowing the tree to grow around the hardware and insects & moisture to collect beneath. Care should be taken to ensure that the proper aiming angle is maintained. Allow an extra 6-inches to 12-inches of cable at each fixture location for any future service work. Ensure that all connections are solid and waterproof.

The AOLP recommends using hanger-bolts for this application as they will allow service personnel to make future adjustments without worrying about the tree overtaking the fixture. Check tree bracket installations annually to verify that proper clearance is maintained.

It is NOT acceptable to attach a fixture or cable directly to the tree by any of the following methods; staples, screws without any stand-off ability, wire or metal tie straps, or any other method of flush-mount attachment to the tree.

Tree fixtures should be pre-assembled prior to climbing into a tree. Cable connections should be made on the ground, so solid, waterproof connections and proper lamp operation can be confirmed safely prior to final installation above ground.

Contractor should first identify from the ground the exact fixture placement onto any part of the tree. For added safety, the contractor should utilize a tool belt with pouches to carry all necessary tools and parts for this installation process. In addition, quick-release safety lines should be attached to heavy tools in case they are dropped while up in the tree.

Tree work can be dangerous and only those with proper training and equipment should perform this installation work. The contractor should ensure the safety of the climber at all times. This includes the use of safety belts and lanyards and/or a properly placed extension ladder. Ladders should be tied-off or secured to prevent movement or falling.

Attach hanger-bolts so that they are properly positioned prior to fixture placement—use a mounting template or fixture base to align hanger-bolt placement. A pilot-hole should be drilled prior to bolt installation to allow for easier attachment. Tighten each bolt assembly (bolt and one nut) through the outer bark of the tree. Place the fixture assembly on to each aligned hanger-bolt and ready it for final lock down. Thread on the final securing nuts to lock fixture in place without movement and then adjust this position to ensure that the fixture unit is off-set from the tree to the appropriate clearance.

Pre-aim all tree fixtures during the day time hours so that night time adjustments will be minimal. Contractor should ensure that the landscape lighting designer is present for these final night adjustments, so that the design intent of the project is captured and approved.

E.5.4 Underwater Fixtures

Underwater low voltage lighting fixtures are used in bodies of water NOT meant for humans to occupy. These fixtures can be installed a variety of ways, but it is most important to protect the cabling and fixture from any damage. All cable junctions or connections should take place outside of the water source. Underwater fixtures can be set in place with their associated weighted base assembly, or they can be securely installed within rocks or plants. It should be noted that lamp or LED changes need to occur above water, so either the fixture needs to have enough extra cable to allow for that or the contractor will need to drain the body of water to gain access.

The installation and use of underwater fixtures have special restrictions and must follow all NEC and local codes. Fixtures must be rated as "submersible," and they must be listed for their intended application.

Non-permanent, unsecured fixtures and cable runs should be placed within the water feature to best hide these components. Rocks, stone, or other building materials can be used to hide the cabling and fixture(s), but they should not crush or damage this equipment.

Permanent, secured fixtures and cable runs should be installed in conduit to a pre-determined location for optimum performance. All conduit that is terminated outside of the water source should be located at a minimum level of 8-inches above the water level at the water feature.

The contractor should ensure that there are NO cable connections within the water feature area at any time. Each underwater fixture should be manufactured with enough cable length to reach outside of the water feature—this may require custom cut cable to be specified.

E.6 Underground Conduit

*Conduit or "sleeving" is recommended for those areas of the landscape where damage protection and/or ease of cable access might be required. Refer to **Section D.7, Conduit & Sleeves**, for further details.*

All electrical conduits must use sweep bends (90-degree and 45-degree) to ensure that cabling can be easily pulled from one point to another. A maximum of four (4) consecutive turns is allowed before a pull-box must be installed or the cable must be terminated--refer to NEC and local codes.

Never use irrigation fittings to make turns—cable cannot be pulled through these tight angles. Conduit for electrical wire should always be grey in color.

All sleeves under hardscape areas must extend 4 inches minimum, beyond the outer edge of these elements. Sleeves should always be used when passing through concrete footings and walls or any other structural element.

Section F: Maintenance

A maintenance service program should be established up front with the owner of the landscape lighting system for all future service work. There are basic maintenance services that need to be accomplished to ensure the following: 1) longevity of the lighting system, 2) performance of the system, and 3) correct aiming adjustments are made to ensure the design intent of the project.

*The AOLP highly recommends that its members or the installation contractor prepares an As-Built plan for the project. This should be done prior to the contractor being released from the job. These final installation records are important to the successful and continued operation of the system with any future maintenance services. These plans should identify the locations of sleeves or conduits, cable runs, fixtures, transformers, 120-volt power supplies, controls and any other element that would aid in future servicing of the system. Refer to **Section C.8, As-Built Records** and **Section C.9, Installation Records**.*

Record documents should be kept by the lighting maintenance service provider or owner. These records should include an As-Built plan. The installation contractor should maintain records of his/her work for a minimum period of three (3) years. The owner of the landscape lighting system is ultimately responsible for initiating all service work and future maintenance to the lighting system.

F.1 Service Agreements

Maintenance agreements should be used to control various aspects of any future service work whether it is "requested" or "routine." These agreements should address what services are to be performed, who will perform them, when they will be performed, and the associated costs of any service function.

The AOLP recommends that its members help to guide their customers with the service frequency necessary for the job—this can be either "routine" in nature or "requested" and on an as-needed basis.

F.2 Service Work

All service work should be documented to show a history of the following: 1) what has been done to maintain the system, 2) where problems have occurred, and 3) suggestions for improvement to the system.

Record documents are important to ensure system performance and the original design intent. They should be available to the landscape lighting designer, the service provider or lighting maintenance contractor, and to the owner.

F.2.1 Lamp & LED Retrofit Sources

The lamp or LED retrofit light source is the most important element of any lighting system, because that is the light you see. Due to lamp construction methods and their sensitivity to damage, most incandescent lamp manufacturers do NOT warranty their products. LED retrofit sources each have their own individual warranty, so they should be individually addressed at the time of purchase. Incandescent lamp life (in hours) is estimated based on a set of laboratory tests performed to find the average life where 50% of the total quantity of test lamps fail or burn-out. These average life estimates are dependent on not only manufacturing conditions but also on environmental use conditions, and these factors make it difficult to offer any guarantee regarding incandescent lamp performance. LED sources for exterior use are still relatively new and the technology is changing rapidly. This contributes to a significant amount of change in the marketplace.

The AOLP recommends that its members identify the lamp type or light source used in every fixture on the project. This will aid in all future service work. Records should be kept as part of the As-Built documents.

All light sources, whether incandescent lamps, LED retrofits, or LED integrated fixtures, should be identified within the Record documents. There should be a minimum amount of information provided: 1) lamp or LED source/ manufacturer description, 2) wattage, 3) voltage range, 4) beam spread in degrees, 4) color temperature in Kelvin, and 5) ANSI code, if available.

Incandescent lamps and LED retrofit servicing should include the lubrication of the metal pins and/or the socket assembly contacts with a di-electric grease or silicone product. This service should be done at each new lamp installation. This will aid in the prevention of oxidation between the metal contacts of the socket and lamp or LED base.

Servicing of halogen bi-pin lamps (those without an exterior reflector housing--MR-style) should NOT be touched by the service worker's fingers. A cloth or protective wrap, such as the protective plastic bag that covers the glass bulb, should be utilized to keep finger oils off of the glass envelope.

Any oils deposited onto the glass bulb envelope of a halogen lamp will allow heat to concentrate there and that can compromise the glass surface allowing the gas to escape and moisture to enter the lamp thus leading to premature failure.

F.2.2 Fixtures & LED Integrated Units

The fixture is the entire package that holds the lamp or LED source within its protective exterior housing and it must be serviced on a regular basis to ensure its functionality. The location of these units should be shown on the As-Built plan.

Fixtures and LED integrated units should be identified on the As-Built plan and recorded in the record documents. This description should include the following minimum amount of information: 1) manufacturer, 2) model number, 3) finish/paint color, 4) lamp or light source type, 5) accessory items, 6) mounting type, 7) aiming information, and 8) warranty information.

Fixture servicing should include minimum routines: 1) cleaning of the exterior parts, 2) cleaning of the water deposits/calcification on the glass lens, 3) lubrication of threaded hardware, 4) inspection and lubrication of O-rings & gaskets, and 5) inspection and repair of any damages.

Fixture adjustments should be made, as required, for any fixture located near trees or plant materials. All tree-mounted fixtures should be visually inspected on a regular basis and adjusted as necessary—a minimum of every 12-months.

Adjustments to hanger-bolts should be performed, as necessary, to ensure that the fixture is a minimum of 1/2-inch away from the tree surface. Hanger-bolt nuts should be adjusted out to allow for this off-set clearance. However, at some point the contractor may need to back out the hanger-bolts to allow for added clearance.

Tree-mounted fixtures will require periodic inspection of the cable attachment to the surfaces of the tree. Visual inspections should be performed to ensure that cabling is NOT damaged from animals or rodents and other landscape service providers. The contractor should pay attention to the base of the tree where the cable enters the soil and to the horizontal branches where cable is exposed to rodent travel routes. A protective section of conduit or sleeve might be necessary to protect cable at the base of each tree.

Fixtures with glass lenses should be inspected for water deposits and mineral build-up. Any build-up should be cleaned away from the glass by either physically scraping or by a chemical cleaning process. A sharp blade or knife can be used to scrape away debris or a cleaning agent, such as concentrated citrus oil or a de-calcification product. This service should occur on an annual basis or as needed to ensure that light transmission through the lens is maintained.

Fixtures should be inspected for damage created by landscape service workers, pets, or any other physical action. If these fixtures are located in and exposed to extreme environmental conditions, then inspections should occur more frequently. These conditions might be snow or ice, desert heat, ocean salt spray, or other direct chemical attacks like de-icing salts or fertilizer applications. The service provider should pay close attention to all sensitive fixture components--O-rings, gaskets, lenses, paint finish, etc. These types of harsh conditions may warrant the use of high-grade composite or brass fixtures (not painted aluminum products).

There are fully integrated LED source light fixtures available and these have their own warranty package. Because the solid state lighting industry (LED is one type of solid state lighting) is still evolving these integrated LED units are continuously changing, and the industry has not stabilized with a set of "standards." Therefore, it is advisable that the consumer become educated about LED lighting before making a purchase decision.

LED integrated fixtures should only require periodic cleaning of the fixture exterior, to include the lens face. Should a unit fail, it should be disposed of or returned to the manufacturer if it is still under warranty.

F.2.3 Transformers

Each transformer should have its interior compartments and exterior housing visually inspected. These units should be identified on the As-Built plan and within the Record Documents.

Record documents should include the following information on each transformer: 1) manufacturer, 2) model number, 3) finish/paint color, 4) size (capacity), 5) incoming voltage (120-volt), 6) total fixtures on system, 8) control device type(s), and 9) zone ID number.

Record documents should include all necessary electrical system information: 1) total primary side (120-volt) amperage, 2) individual secondary side (12-volt) amperage per circuit or run, and 3) actual voltage at secondary side voltage taps in the transformer. It is best to include the date and time of day when the readings were taken due to fluctuations that might occur with power use.

Transformers require a minimum amount of routine service: 1) cleaning of all exterior parts, 2) cleaning of interior compartment spaces and internal lugs, 3) lubrication of door hinges, latches, and locking assemblies, 4) re-tightening of all lugs and/or wire connectors, and 5) inspections for electrical damage or general wear-and-tear issues.

The service provider should verify the current amperage load reading as compared with that of the original installation. This will allow the contractor to see any variance to the system performance and act accordingly. System variances might indicate any one of the following:

- Incoming line voltage (120-volt) changes
- Short circuits in the system—possible cuts or nicks in the cabling
- Someone changed a lamp using the incorrect wattage

F.2.4 Controls

Control devices and systems can vary greatly in performance and cost. They can be modular and of a plug-in type or they can be of a hard-wired type. Some are very intricate and perform within the site's 120-volt electrical system, while others perform by radio frequency (RF) or entirely on the low voltage side. In either case, there may be a need for another professional service to maintain these components, especially if programming is involved.

All control devices should be listed within the Record Document set and any services performed to these units should follow the manufacturer's requirements.

Record documents should include the minimum information on each control device: 1) manufacturer, 2) model number, 3) electrical ratings and load, 4) device settings and codes, if applicable, and 5) warranty information.

Servicing of the control system and/or any devices requires routine inspection, light cleaning, and testing to ensure they are properly functioning. Most electrical devices or controls are sensitive to moisture and the exterior environment, therefore, these components may become faulty over time and may not be serviceable. If unserviceable and not under warranty, the devices must be discarded and replaced.

Inspect all electrical connections of the control device to ensure they are solid and secure.

Replace back-up battery(s) on a routine basis. It is recommended that standard batteries be replaced annually.

Lubricate all necessary moving parts. Ensure that any waterproofing materials or methods used are in good condition.

F.3 Maintenance Supplies

All maintenance service providers should maintain a basic set of cleaning supplies, lubrication supplies, and oxidation prevention supplies to use with lighting system service work.

F.3.1 Cleaners

These materials are used to clean both the interior and exterior surfaces of the transformer as well as fixtures:

- Spray cleaner—preferably environmentally safe and strong enough to remove grease or debris (e.g., "Simply Green" or an all-purpose citrus oil cleaner)
- Cloth towels or industrial type hand towels
- Soft bristle brush, paint brush and/or tooth brush

F.3.2 Lubricants

These materials are used to preserve and protect parts from oxidation damage:

- Di-electric grease—any conductor termination compound that prevents oxide build-up and is good for metal-to-metal contact, aluminum or copper (e.g., "Penetrox A" by Burndy)
- Heavy-duty silicone spray—to waterproof, rust-proof or lubricate rubber, metal, or plastic (e.g., "Liquid Wrench" by Gunk)

F.3.3 Sealants

These materials are used to prevent water from entering an area to be protected from exposure:

- 100% Silicone—there are various types available
- Teflon tape—to be used between metal fittings and threaded part fittings

F.3.4 Tools & Equipment

All maintenance service providers should have the following basic set of hand tools and equipment in order to perform routine service:

- Hand tools—screwdrivers, pliers, channel-locks, wire strippers/cutters, crimpers, hex-wrench (Allen wrench) set, utility knife, awl, hack saw, hammer, small flashlight, and torpedo level
- Electronic tools—multi-meter, amp probe, and any other electrical testing device
- Landscape tools—trenching shovel, flat end shovel, small rake, and broom
- Other tools—cordless drill/driver, extension cord, drill bits, small portable work bench, etc.

F.3.5 Lamp Inventory

Inventory of lamps and LEDs can be even more challenging now that LED is a driving force. If incandescent lamps are utilized, then inventory is typically not too difficult and is not costly. However, LEDs pose a new dilemma as there are so many varying brands, types, etc. and whether or not they are LED retrofit lamps or fully integrated LED fixtures. The biggest challenge is the cost of these individual units (6x to 60x higher cost factor over incandescent lamps). The goal is to maintain a reasonable stocking level of the common lamps or LEDs that are used on any given project—planning is very critical.

Lamp specifications are critical to ensure the design intent, so pay particular attention to the wattage, beam spread, color temperature, and voltage of each unit. The following list shows the standard incandescent lamps found on most jobs:

- MR - Multi-mirrored Reflector
- PAR - Parabolic Aluminized Reflector
- AR - Aluminum Reflector
- T - Tubular
- Bayonet base
- Wedge
- Cartridge (Festoon and Rigid Loop)

F.3.6 Spare Parts and Accessory Items

All maintenance service providers should have access to or carry with them the following list of parts and supplies—this is a basic list and should be adapted to the types of services provided:

- Electrical tape (black) and colored electrical tape for identification purposes or numbered tape
- Duct tape
- Composite ground stakes and/or metal ground stakes
- Glass lenses—clear, frosted, linear spread, prismatic, and colored lenses, if necessary
- Glare shields
- Spare essential fixtures—brand specific and depending on job
- O-rings, gaskets, screws, fittings, and other brand-specific spare parts
- Sockets/socket assemblies—all types that are installed on job
- Cable—enough supply for additional runs or repair work
- Connectors—various sets of wire connectors, butt-splices, spade-connectors, etc. to perform any type of connection on different wire gauge sizes
- Heat-shrink tubing kit or solder kit—depending on method of waterproofing employed

Concluding Statement

The Association of Outdoor Lighting Professionals (AOLP) is proactively involved in the advancement of the low voltage landscape lighting industry, and we serve to educate not only our members but anyone interested in utilizing these Guidelines. The creation and development of this document set is for the sole purpose of "raising the bar" for all professionals performing these installations or services.

By no means does the AOLP intend to propose or encourage any installation practice that is counter to the National Fire Protection Agency (NFPA), as it is the governing body for all electrical installation practices as described in the National Electrical Code (NEC). The AOLP has put together a panel of experienced members within the trade to include contractors, electricians, designers, and manufacturers and distributors to oversee future revisions, updates, and code changes that might apply to this working document. Any questions or comments regarding the content of this document may be directed to the Executive Director of AOLP at 717-238-2504 or information@aolponline.org.