Low Voltage Landscape Lighting Trade Specifications

Professional Standards & Practices

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Landscape Lighting Trade Specifications 2015

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Section A: General

A.1 Landscape Lighting Description

The term "Low Voltage Landscape Lighting System," whether intended for landscape or architectural use and for the purposes of this document, shall be referred to as permanently installed landscape lighting systems. This includes the use of transformers and cabling for the purpose of illuminating landscape environments and the exterior of structures or buildings.

A.2 Purpose of Guidelines

These Guidelines are intended to be utilized to support any low voltage landscape lighting system installation and their associated practices. They should be used by both the contractor and the consumer, as a means for understanding what is be expected during these processes. Additionally, they will serve to improve the professionalism, quality and craftsmanship of this trade discipline.

Section B: Lighting Designs and Agreements

B.1 Lighting Designs

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 information that is necessary for the installation of these landscape lighting systems. The information presented should address the what, where, when, and who is to perform this work, so that all parties can have this understanding. 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 this understanding. 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) the visitation of other job sites, and/or 4) computer applications that use lighting software.

B.2 Installation Agreements

The contractor should supply the customer 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 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 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

Maintenance agreements serve to primarily describe the costs and frequency of visits during a set period of time, 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 world's leading advocate of fire protection and that also is an authoritative source on public safety is the National Fire Protection Agency (NFPA). It regulates and recognizes NFPA 70, also known as the National Electric Code (NEC), as the leading source for adoption by federal, state, county and municipal governmental entities. The most current edition of the NEC is dated August 1, 2013 (NEC 2014). More than 15 of the United States have started the process to update their code use. Many states are still utilizing the 2011 and 2008 editions.

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 local and municipal 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.

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 should be considered at all times and above all else. Communication between all parties is critical—any unsafe act or condition found should be brought to the attention of the contractor in-charge. Each sub-contractor or service company on site should be responsible for his/ her own crew and they should have their own set of safety practices to follow.

Other than "Acts of God", all accidents are preventable. Every accident or injury is the result of; unsafe or ineffective procedures, unsafe physical conditions, unsafe equipment, unsafe personal acts, and is usually one or more of these factors in combination.

The primary goal of the contractor is to perform all work in the safest manner possible that is consistent with good construction practices. There are three (3) procedures that should be in place prior to starting any job, which will aid in the prevention of job-related injuries:

- Identify who is responsible and in-charge for all operations on site
- Identify and properly mark all hazards present on site prior to starting and during daily service activities—note unsafe conditions
- Communicate or identify any hazard to all employees and/or anyone present in the work zone(s)

The contractor should supply or make available, the following items at each job site:

- Drinking water
- First-aid kit and fire extinguisher
- Basic personal protective equipment—safety glasses, hearing protection, hard hats, dust masks or respirators, gloves, and safety belts & lanyards

A site review or "hazards analysis" should be performed by the contractor in-charge, prior to starting any work. These "hazards" should be identified and explained to all employees on-site, and a thorough explanation of what is expected by all employees if an injury or accident takes place should be provided. This is most critical in the event of fires or major accidents. The following list of potential "hazards" should be discussed as these are common occurrences:

- Buried utilities
- High voltage devices and equipment
- Working around other contractors, equipment, and heavy traffic
- Parking conditions
- Slips and falls
- Cuts and burns
- Plant and animal conditions—toxic or poisonous and pets on site
- Harsh or extreme weather conditions—sun & heat, snow/ice & cold, rain & mud
- Chemicals on site and flammable materials or conditions

The contractor in-charge should have a basic set of Safety Rules to follow and they should properly communicate these rules and expectations to all installation team employees. The following list includes components of these rules:

- 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 and other unacceptable behavior on site

C.5 Materials & Workmanship

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 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

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 any incandescent or halogen lamp (bulb) manufacturer. 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-Build Records

As-Build plans should include enough information to locate all equipment used with 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-Build information should be kept by the installation contractor for a minimum of five (5) 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

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 #)
- 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 other wiring from others)

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

D.1 Materials Selection

The installation contractor should only utilize products that are "listed" for their intended use with landscape lighting systems. The National Electric Code (NEC) governs all installation practices used with the establishment of these systems. You are advised to check your local agency for the current code book being used or see www.nfpa.org for a state by state listing.

All landscape lighting products are required 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 manufactures 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

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

Low voltage transformers that are acceptable to use, but are NOT compliant under **UL 1838**, are those that allow voltages 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 this application and **submersible fixtures**. Transformers supplying power to any "underwater fixtures" located in a pool or spa application (human use) must be rated as a **pool and spa rated transformer.** These "pool and spa" rated units have added electrical protection, called a Faraday shield, that isolates the line-voltage from the low-voltage components within the transformer. Refer to all NEC and local codes for more details.

> **NEC 2014, article 680.23 (A)(2)—Transformers and Power Supplies:** Transformers and power supplies used for the supply of underwater luminaires, together with the transformer or power supply enclosure, shall be listed for swimming pool and spa use. The transformer or power supply shall incorporate either a transformer of the isolated winding type, with an ungrounded secondary that has a grounded metal barrier between the primary and secondary windings, or one that incorporates an approved system of double insulation between the primary and secondary windings.

D.3 Cable

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 polyvinyl chloride (PVC). 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" for polarity and the other leg is "plain" and shows identification markings that are either ink printed or wire indented. 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

The contractor should ensure that all light fixtures are **UL 1838** listed.

NEC 2014, article 680.22 (B)(6)—Low Voltage Luminaires: Listed low voltage luminaires not requiring grounding, not exceeding the low voltage contact limit, and supplied by listed transformers or power supplies that comply with 680.23 (A)(2) shall be permitted to be located less than 5 ft. from the inside walls of the pool.

Low Voltage Contact Limit

- **15 volts (RMS) for sinusoidal AC**
- **21.2 volts peak for non-sinusoidal AC**
- **30 volts for continuous DC**
- **12.4 volts peak for DC that is interrupted at a rate of 10-200 Hz**

NEC 2014, article 680.33 (A)—Luminaires, Within the Low Voltage Contact Limit: A luminaire shall be a part of a cord-and-plug connected lighting assembly. This assembly shall be listed as an assembly for the purpose and have the following construction features:

- No exposed metal parts
- A luminaire lamp that is suitable for use at the supplied voltage
- An impact resistant polymeric lens, luminaire body, and transformer enclosure
- A transformer or power supply meeting the requirements of 680.23 (A)(2) with a primary rating of not over 150 volts

D.5 Wire Connectors

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

All wire connectors used in the exterior, outdoor environment should be waterproofed before being placed within the soil. 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 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 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, as long is has enough strength to avoid crushing or breakage 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 overall governing document that supersedes these Guidelines is the National Electric 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

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.

NEC 2014, article 680.22 (A)(4)—GFCI Protection: All 15 amp and 20 amp, single phase, 125 volt receptacles located within 20 ft. of the inside walls of a pool shall be protected by Ground Fault Circuit Interrupter (GFCI).

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 apply an in-rush, overload current through the breaker.

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

NEC 2014, article 680.22 (A)(1)—Required Receptacle Locations: Where a permanently installed pool is installed, no fewer than one 125 volt, 15 amp or 20 amp receptacle on a general-purpose branch circuit shall be located not less than 6 ft. from, and not more than 20 ft. from, the inside wall of the pool. This receptacle shall be located not more than 6 ft. 6 in. above the floor, platform, or grade level serving the pool.

NEC 2014, article 680.22 (A)(3)—Other Receptacle, Location: Other receptacles shall be not less than 6 ft. from the inside walls of a pool.

NEC 2014, article 680.34—Receptacle Locations: Receptacles shall not be located less than 6 ft. from the inside walls of a storable pool, storable spa, or storable hot tub.

E.2 Transformers

All transformers should be sized to allow for any future increase in system load, to include the resistive values associated with longer cable run distances. 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. Cable runs should NOT exceed 80% of its rated capacity for the gauge size used. Multi-core transformers should have their loads 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 these problems.

Transformer mounting should follow all manufacturer recommended procedures. The contractor should use all available mounting slots to secure its 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 siding, metal, or masonry. Transformers can be post-mounted, but care should be given to the solidity of this method 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 entering the receptacle box.

Transformers that are hardwired directly to the electrical system should utilize an alternative means of shut-off of this primary power in the event of an emergency.

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 color or a numbering 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 the gravel sump—at least a 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 water-proofed.

Water-proofing 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

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 damages to materials placed below. It might be preferred to use conduit in these areas for added protection.

Cable runs in annual or perennial beds should be placed in Schedule 40 or better conduit and buried a minimum of 6-inches in depth. These landscape areas require frequent work or seasonal changes and therefore, allow the cable to be 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 its toxicity to the tree. Cable and fixtures should NOT be directly attached to the tree with staples or tie-wraps as they will either engulf or choke off that section of the tree.

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 2-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 enough 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—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

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 below, then the proper size connector should be used to maintain a proper connection. Contractor should ensure that all lugs not used in the terminal block are fully closed, to prevent arcing between foreign objects.

Connections made by twist-on wire nuts should utilize the proper size wire nut to ensure a strong connection—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 water-proofed to ensure the integrity of the lighting system.

E.5 Fixtures

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, to include their wattage limitations.

E.5.1 Ground-mounted Fixtures

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

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

Stakes should be either hammered in place or a hole can be excavated to allow the stake to be completely buried and exposed only at the top surface of the finished grade. The soil surrounding the fixture should be compacted back in 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 require additional depth to allow for the added weight being supported at higher levels. This post depth should be from 25%-33% of the post length and they can be either set directly into the soil or into a concrete sub-base.

E.5.2 In-grade Fixtures

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 surround grade to prevent water from settling in at the fixture.

All in-grade fixtures located in "softscape" areas should have a extra 3-feet to 5-feet of cable bundled and located at the base of each fixture or within the well light shell 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 from 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, decomposed granite, etc.) up to and under the edge of the well light face cover.

Final adjustments and aiming should be performed before locking down 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 a extra 12-inches to 3-feet of cable bundled and located within the well light shell housing.

Conduit should stub-out or up into the shell 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 shells or 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 shell or fixture housing by utilizing re-bar and wire tie or any other equivalent method, so that the fixture housing will NOT move during the concrete or masonry installation. It is suggested that the contractor oversee this work, as many damages can occur.

Install a fabricated shell housing lid or cap to the open top end, so that the interior space of the shell 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 shell 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 water-proofed.

Install the proper 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 locking down these settings.

E.5.3 Above-grade Fixtures

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 a extra 6-inches to 12-inches of cable at each fixture location for any future service work. Ensure that all connections are solid and properly water-proofed.

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 avoid glare issues as best as can be from any primary viewing angle of this position.

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

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 stand-off of the trunk or branch by at least 1/2-inch to 1-inch in clearance, to ensure that the tree does not grow into the attached fixture. Care should be taken to ensure that the proper aiming angle is maintained. Allow a extra 6-inches to 12-inches of cable at each fixture location for any future service work. Ensure that all connections are solid and properly water-proofed.

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 direct 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 that assurance can be obtained with solid connections, water-proofing, and proper lamp operations.

Contractor should first identify from the ground level, 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 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) into 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

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.

Temporary, 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, 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 feature—this may require custom cut cable to be specified.

E.6 Underground Conduit

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 all 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 consumer 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.

Record documents should be kept by the lighting maintenance service provider or consumer. These records should include an As-build plan. The installation contractor should maintain records of his/ her work for a minimum period of five (5) years. The consumer and/ or owner of the landscape lighting system is ultimately responsible for all service work and future maintenance to this 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.

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.

F.2.1 Lamp & LED Retrofit Sources

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.

To ensure consistency, color rendition, and lamp/LED performance, replacements should be of the same brand, model #, beam spread, wattage, and Kelvin temperature, as originally installed. This practice should be developed to ensure the lighting design's intent and overall system integrity.

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 shell--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.

F.2.2 Fixtures & LED Integrated Units

Fixtures and LED integrated units should be identified on the As-Build plan and recorded in the record documents. These fixture units 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-month's.
>
> > Adjustment to hanger-bolts should be performed, as necessary, to ensure that the fixture is a minimum of 1/2-inch to 1-inch away from the tree surface. Hanger-bolt nuts should be adjusted out to allow for this off-set clearance. However, there may become a 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, such as calcium build-up. Any build-up should be cleaned away from the glass by either a 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 can be maintained.
>
> Fixtures should be inspected for damages 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.

LED integrated fixtures should only require periodic cleaning of the fixture exterior, to include the lens face. If these units fail, then they should be disposed of or returned to the manufacturer—as long as they are still under warranty.

F.2.3 Transformers

All transformers should be visually inspected at its interior compartments and its exterior. These units should be identified on the As-Built plan and within the Record document's set.

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. side), 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 amperage, 2) individual secondary side 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 services: 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 amperage load reading as compared with that of the original after 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 in the cabling
- Someone changed the lamps using the wrong wattage

F.2.4 Controls

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 environments, therefore, these components may become faulty over time and may not be serviceable—they may not fall under warranty and must be discarded.

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 and oxidation prevention supplies to use with lighting system service work.

F.3.1 Cleaners

These materials are used to clean both exterior housings of transformers & fixtures and the interior components of the transformer:

- Spray bottle with 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 or paint brush or tooth brush

F.3.2 Lubricants

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

- 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
- Liquid Electrical tape—paint on waterproofing sealant for various applications

F.3.4 Tools & Equipment

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

- 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 cords, drill bits, small portable work bench, propane torch, staplers, bench vise, etc.

F.3.5 Lamp and LED Retrofit Inventory

If plug in lamps and retrofit style LED's are used, then these lamp specifications are critical to ensure the design intent. Pay attention to the wattage, beam spread, color temperature, voltage, and date code (if applicable) with each unit. Whether you are working with incandescent, halogen, xenon, LED retrofit or any other light source, you should have a variety of spares on hand for repairs and maintenance service work. The service provider should understand the various types of socket bases available to connect these light sources.

F.3.6 Spare Parts & 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 listing 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 gauge size of wiring
- Heat-shrink tubing kit or solder kit—depending on method of waterproofing employed