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Disclaimer

The Association of Outdoor Lighting Professionals (AOLP) *Standards for Outdoor Lighting Professionals*, herein after referred to as "the standards", is intended to be an educational and reference tool for *low voltage* lighting professionals. The standards are not meant to supersede any electrical code or governing authority. While every effort has been made to provide accurate information the AOLP is not liable for any inaccuracies and also reserves the right to change these standards without notice.

Chapter 1

Low Voltage Landscape and Architectural Lighting Systems Defined

The term low voltage landscape and architectural lighting, for the purpose of these standards, refers to permanently installed outdoor lighting fixtures operating at 12 volts or less, which illuminate landscape environments and exterior structures. Components of these systems typically include transformers, switching devices, multi-strand wiring, wire connectors, fixtures and lamps and other accessories.

Common Terms & Definitions

CE Code – Canadian Electrical Code provides the signature standards for addressing shock and fire hazards of electrical products in Canada.

CIRCUIT – The complete path of an electric current including usually the source of electric energy.

CONDUCTOR – A substance that allows the passage of an electrical current through it.

C.S.A – Canadian Standards Association. A testing and standards organization. Certifies fixtures and transformers for residential and/or commercial use, amongst other products as well. Primarily recognized in Canada and the British Isles.

CURRENT – The flow of electricity through a conductor.

DYNAMIC WATTAGE – The actual on-site measured wattage requirement. Dynamic wattage takes into account the “effective wattage” adjustment as well as other variables that impact system voltage demand.

ETL – Electrical Testing Laboratories is a product testing and certification service company

FIXTURE – A tool for holding the correct lamp in a secure low maintenance way.

FOOT CANDLE – Common measurement of light intensity in the U.S. Equals the amount of light cast by 1 candle on a 1’ x 1’ square from a distance of 1’. One foot candle equals 10.76 LUG.

GFCI – Ground Fault Current Indicator. Used in outdoor 120-volt A/C receptacles to prevent electrical shocks. N.E.C. now in many areas requires a GFCI outlet on all outdoor, bathroom and garage receptacles.

GLARE – Unwanted light, especially light from a source falling directly into the eye.

INCANDESCENT (lamp) – Produces light (and heat) when a thin wire filament is excited by electrical current.

KELVIN TEMPERATURE (K) – Color (whiteness) of light. The actual color (from red up the spectrum to blue) of a lamp's output is rated in degrees Kelvin (K). K indicates only color; it has nothing to do with the light's intensity or heat temperature.

LAMP – Device used to convert electrical energy to visible light energy. Usually a glass globe filled with an inert gas in which a wire filament is heated by passing electrical current through a resistive element until the element glows. Lamps, being luminous, produce heat as well as light.

MAGNETIC CIRCUIT BREAKER - A device used to protect a circuit from shorts and overloads by detecting the rise in electrical current from the increase in the magnetic field generated.

MR – Multi-mirrored reflector quartz-halogen lamp. (MR16, MR11, MR8)

N.E.C. – National Electric Code

PAR – Parabolic Aluminized Reflector lamp. A sealed beam lamp similar in design to an automobile headlight, but usually smaller. NOTE: the diameter of PAR lamps is measured in 1/8's of an inch. For example, a PAR-36 lamp has a diameter of 4.5".

PHOTOCELL – A switch activated by the presence or absence of light to control a circuit.

QUARTZ-HALOGEN LAMP – Quartz globe filled with halogen gas. These lamps burn brighter (whiter) than standard incandescent lamps.

RESISTANCE – The opposition offered by a body or substance to the passage of an electrical flow (CURRENT) through it.

SHORT CIRCUIT – Direct connection between two sides of a circuit without passing through the electrical device. Usually accompanied by smoke, sparks, and a lot of excitement.

THERMAL CIRCUIT BREAKER – A device used to protect a circuit from shorts and overloads by sensing heat produced by such.

TIMER – An analog or digital device used to control a circuit by time.

TRANSFORMER – A device comprised of a series of copper wire windings that reduce 120-volt A/C to 12-24 volts A/C. The device may also include timing mechanisms, sensors, etc.

U.L. – Underwriters Laboratories is a testing and certification service company.

VOLTAGE DROP – Energy lost in overcoming resistance in a circuit.

VOLTS – Measurement of electrical potential and electromotive force. Voltages higher than 15-volts may be dangerous.

WATT – 1/746 horsepower; standard measurement of work done at 1 amp x 1 volt.

WIRE CONNECTOR – An approved device used to connect two or more wires.

XELOGEN (lamp) – A heavy, odorless and relatively inert gas used in high-voltage and some low voltage lamps.

Chapter 2

Sound Business Practices

All business owners and operators are responsible for complying with the business standards of the governing authorities where they operate. The most common of which include licensing, insurance, taxes, permits, codes and ordinances, and bonding. These things vary from state to state and municipalities within the states. While one state may require all of the above-mentioned criteria others may have no requirements. As a professional it is your responsibility to know what is required. This will protect you as well as your clients.

Additionally, there are sound business practices that all professionals should incorporate. These can include such things as responding to your clients in a timely manner, dressing professionally, keeping your vehicle clean, ensuring communication between your client and site crews, maintaining an organized and orderly job site, and if nothing else make sure you DWYSYWD (do what you say you will do).

Insurance

The two most common types of business insurance are liability and workers compensation. Liability insurance is coverage to protect against claims alleging that one's negligence or inappropriate action resulted in bodily injury or property damage. Workers compensation on the other hand is a system of compensation for work related injuries or death, paid for by employer compensation insurance contributions.

Bonding

Compliance guarantee license bonds are usually required by a governmental entity and guarantee that the Principal will conduct business in accordance with the privilege granted by a particular license and he/she will comply with the governmental ordinances. Ultimately, these bonds protect the public from incompetence and hold the governmental entity harmless.

Codes & Ordinances

A contractor shall become familiar with and abide by all federal, state, and local codes including NEC / CEC.

Contractors should also become familiar with and abide by all Occupational and Safety Health Administration (OSHA) regulations specific to the work being performed and maintain a safe work environment at all times.

The Value of Maintenance

It may seem unusual to include maintenance in a guide for installation standards, but we would be remiss to not mention it. Most consider maintenance as an after thought when in fact it should be considered at the beginning of the design phase.

Establishing how a system will be maintained will assist you in both design and installation. For example, for a client who intends to do the maintenance themselves downlighting from trees may not be appropriate. Despite the availability of longer life lamps the client will have to adjust wiring and eventually the lamps will need replacing.

On the other end of the spectrum it's important to discuss maintenance with your client again after installation. Always provide your client an as built regardless of who's going to maintain the system. Make sure the client understands maintaining their system will yield them years of enjoyment as well as ensure the value of their investment.

Remember, the most beautiful and well designed lighting systems are worthless if they are not properly installed and maintained.

CHAPTER 3

Initial Meeting with a Client

An initial meeting with a client should establish their needs and expectations as well as what you have to offer them. Tools to accomplish this may include a pre-established list of general questions, a portfolio of your work, and client references. If you have any formal education or certification this too should be presented. You may also want to include in your presentation a couple of product samples to show the quality of the materials you use.

Once you establish the client's needs and expectation you will be able to produce an appropriate design and means by which you will achieve it. This may be conveyed through an evening demonstration, verbal description, night photos of lighting effects, an actual design plan, or a combination of these. You may also find it a good time to discuss system maintenance.

In some cases the client may be ready to sign an agreement during the initial meeting therefore having a standard contract with you is recommended. At minimum the agreement should contain the following:

a. Description of the scope of work inclusive of the lighting design.
b. Total cost to the client of the project.
c. Warranties
d. General specification
e. Start and finish date, if applicable by law.
f. Signature line

Let the client know that in the event of changes to the original agreement, by either party, a signed Change Order will need to be secured prior to the changes being made. A change order should include a description of the changes requested along with applicable costs and changes to completion times. Make sure to get the clients signature on the change order. Even if change orders are not required by law in your area this document can be invaluable in the event there are any questions at the end of a project.

Chapter 4

Project Preparation

Use the following checklist as a guide prior to the start of any project. You can make copies of this page and include them with your project documents.

- ❑ Secure necessary permits.
- ❑ Contact your local utility marking companies to mark all underground utilities associated with the project site. This should be done five (5) to seven (7) days prior to the start of the project.
- ❑ Confirm project schedule with subcontractors you'll be using.
- ❑ Secure project materials.
- ❑ Check that all machinery necessary for the job is in good working condition.
- ❑ Prep work site by marking wire runs, fixture and transformer locations, ?????

Chapter 5

Installation

Transformers

1. Locate 120-volt power
2. Determine transformer load
3. Be aware of transformer location

LOCATE 120-VOLT POWER

Ideally, the transformer will be centrally located within the area to be lighted as though it is the hub to the wheel. In many cases, this is not an option. You have to find existing 120-volt power and utilize it from that location or contract with a licensed electrician and have them install a dedicated circuit exclusively for your landscape lighting system. You are guaranteed in these cases you will not have interference on that circuit from other electrical devices and accessories in the home. Switching may be easier in this case since you are dealing with an exclusive lighting circuit.

Use the 120-volt electrical receptacles located at the front and back porches with discretion. These are installed because of code and are intended for temporary use. Also, no one wants their lighting control and power equipment right outside their door. The receptacles should be reserved for holiday lighting

DETERMINE TRANSFORMER LOAD

Add up the wattages of all lamps powered by the transformer. Size the transformer accordingly.

Transformer Capacity (12 VOLTS)	**AMP DRAW 120V SIDE**	**AMP DRAW 12V SIDE**
100	.83 AMPS	8.33 AMPS
150	1.25 AMPS	12.5 AMPS
250	2.08 AMPS	20.83 AMPS
300	2.5 AMPS	25.0 AMPS
500	4.16 AMPS	41.6 AMPS
600	5.0 AMPS	50.0 AMPS
900	7.5 AMPS	75.0 AMPS
1000	8.33 AMPS	83.3 AMPS

WATTS ÷ VOLTS = AMPS (OHMS LAW)

Use the table to determine the amperage draw on the 120-volt side of your transformer so you do not overload the respective circuit. Most residential circuits are 15 amp circuits. For example, if there are existing electrical appliances operating and combined they draw 8.0amps, this would only leave you 4.0 total amps. The total amperage draw on a circuit breaker can't exceed 80% of its rating. (eg. 15 amp breaker equals 12 amp draw maximum).

A 1000-watt transformer would not work in this instance. The draw is in direct proportion to the load. A 1000-watt load would equal an 8.32 amp draw and a 689-watt load would equal a 5.74 amp draw. This is why it's best to work with an electrician and have dedicated circuits installed where possible and feasible. When selecting a transformer, choose a wattage size that gives you some room for future expansion.

LOCATION

Mount the transformers on the residence walls with caution. While most manufacturers use the finest materials to build their transformers, they can occasionally produce a low resonant hum that can be most annoying. This can especially be a problem if the transformer is mounted on the exterior side of a bedroom wall.

Distance from the transformer to a primary breaker does not matter most of the time, but to avoid potential nuisance tripping the transformer should be mounted 15' away from the primary breaker. The transformer is considered a 120-volt device. Use normal precautions when installing. Always shutdown the primary (120-volt) to the transformer when servicing.

Keep the transformer at least 10 feet away from open water and at least 12 inches above grade. Mount the unit higher if the area is subject to occasional flooding and or snow depths.

When installing a transformer with an optional photocell module, be sure the photocell faces away from artificial light sources such as the neighbor's porch lights, streetlights or any part of the lighting installation and has an unobstructed view of the sky. Occasional trimming of plant cover may be required. If possible, the photocell should "see" the northern sky so the system will turn on and off consistently in relation to sunrise and sunset. Pay close attention to keep the sensitive photocell away from direct sunlight.

Look for convenient areas to locate the transformer such as swimming pool equipment areas, electric gates, pump houses, powered boat-docks, swimming pool bath houses, detached workshops and garages. All of the above are good locations to find 120-volt power.

MOUNTING ON WALLS

When mounting the transformer to a wall, always use all of the mounting slots the manufacture has provided. Some of the larger transformers can weigh in excess of forty pounds so the weight must be distributed over all of the mounting slots provided.

Some transformers come with a security slot located within the confines of the weatherproof cabinet. The unit can also be secured to the wall from inside the case. Because many of the mounting slots on the backside of the transformers are keyhole slots, without this inner security screw the transformer could either be too easily lifted up and stolen or too easily knocked off it's mount and cause an injury.

Take a strip of masking tape and apply it to the backside of the transformer's keyhole slots. Mark the alignment of the slots themselves. Then re-apply the tape to the mounting surface of the wall where the unit will actually rest and drill pilot holes through the tape once a precise, level position has been established. Insert the anchors or lag bolts, whatever method that is applicable to this particular situation, and complete the mounting and securing of the transformer.

CONNECTING TO 120 POWER SOURCE

The local electrical code must be investigated to determine what method of connecting the transformer to the 120-volt input is considered acceptable and to code. In many cases it is considered acceptable to connect the transformer to 120-volts through the three-prong grounded plug provided (anything less than a three-prong plug is unacceptable according to the national electric code). Although a three-prong plug is acceptable, some municipal codes require hardwiring the transformer to the 120-volt power source through conduit. This should all to be performed by a licensed electrician.

If using the provided three-prong grounded plug, according to code it must be plugged into a GFCI protected outlet. According to the National Electric Code, all out door, wet area, 120-volt outlets must be protected by a GFCI protected receptacle.

Once the outlet and the mounting location for the transformer have been identified, run the power-cord to the outlet in such a manner that the cord falls down below the level of the outlet and then goes back up to the outlet itself. This creates a “drip loop" so moisture will track down the power cord and drip off instead of running into the outlet, causing excessive tripping of the GFCI apparatus.

CONNECTING WIRE RUNS

Always identify each cable run entering the wiring cavity of the transformer as to it service location and total watts with a wire tab or something as simple as a strip of gray duct-tape. This identification will serve an essential purpose when it comes time to the actual connect of the cables to the power terminals themselves.

If the transformer is equipped with terminal blocks, strip the insulation back on each conductor cable approximately ½” and tightly twist the small strands together. Insert each conductor into the appropriate terminal block, one conductor into the "hot" block and another into the "common" block. Generally, each set of terminal blocks indicate a circuit of x number of watts. According to the National Electric Code, section 411, no branch circuit of a garden lighting transformer should exceed 25 amps (300 watts). Therefore, add up and divide the incoming cable runs and determine the best combination so the total wattage does not exceed the capacity of the circuit.

CABLE INSTALLATION

Low Voltage Direct Burial Lighting Cable is manufactured with a thick insulation jacket in order to protect it (conduit is not necessary unless state mandated). It should be buried in the soil at a 6" minimum depth (in areas such as lawns and flower beds 10”-12” is recommended to avoid damage from tilling or aeration and edging), run across a rain gutter, up a tree or under an eave. Make sure that the cable you use is UL listed. This typically ensures the cable is made from quality materials such as thick pliable insulation, the correct type of copper, the correct number of strands and is the correct size.

A perfect time to install the lighting cable is during an irrigation installation when there are open trenches throughout the property. Even if the homeowner isn’t ready for the lighting system, at least prepare them and get the cable in the ground through the core areas. Divide the property into zones. Consider a lighting design for future use. Consider the different areas that will need light, areas that will be difficult to reach, i.e. islands, under driveways and walkways and install the cable now. If you are installing a lighting system exclusively, you won’t have the luxury of using the open trenches from another project. Or, install conduit and mark it on a plan so you can find it and pull your wires when the client is ready for lighting. While the most direct route from the transformer is best, it's not always the most appropriate path to follow. Always follow hardscape borders and bury the cable along this protective edge. Run the cable along the foundation stem-wall, along the sidewalk but bury deep enough along the walkway so the power edger blade won't cut the cable. Snake the cable along the flowerbed borders on the inside of the beds.

CABLE IN TREES

Attaching cable to a tree should be well thought out. It's always best to run the cable up the backside of the tree, but if your tree is in the center of the front yard, there really isn't a backside of the tree. So, pick the least obtrusive side and run the cable up the tree conforming to tree trunk, tree bark structure and contour.

There are several methods of actually attaching the cable to the tree. A standard u-shaped metal staple will work, but it is not the best device to use, and is not accepted under the AOLP standards of installation. If the staples are not maintained, as the tree grows the staple will begin to cut into the cable and possibly cause shorts. Additionally, if the staples are totally ignored, the tree will actually begin to grow around the cable and staples and permanently disfigure the tree, possibly causing damage that will allow disease to set in and kill the tree.

Plastic J-hooks or zip ties with stainless steel screws work great. Use a 2"-3" screw and set it into the tree holding the J-hook or zip tie approximately 1" away from the tree. As the tree grows, in most cases instead of growing around the wire, the J-hook releases the cable and keeps the tree from becoming damaged and defaced. If the system is maintained properly, the stainless steel screw can be backed out every few years so he tree does not grow into the wire.

FIXTURES ON STRUCTURES

Remember when mounting fixtures overhead, make sure there is no glare in the viewer's eyes. Optional light-shielding accessories can be a solution

When mounting fixtures to structure, always make sure the cable leading up to the fixture is concealed and out of potential view. On wood structures, remove the edge molding and trim and route a groove on the back side of the trim, insert the cable and replace the trim to try creating an invisible installation.

If you are mounting fixtures to painted structures, try to match or compliment the paint finish of your fixture to that of the structure. Also take the necessary steps to provide a method of easy removal in the event the fixture must be removed in order to re-paint the structure.

The idea is to create a visually appealing installation no matter where you are mounting your fixtures. Take the necessary steps to make it a clean and neat installation. Use stainless steel screws and other mounting hardware. Stainless steel will not discolor and stain the lightly painted surfaces or lightly stained woods.

FIXTURES IN TREES

Depending on the fixture and the type of mounting bracket and assembly it has will many times determine what method of installation is best. Most fixtures that are intended to be mounted in a tree or on structures have the necessary provisions to simply "screw" it to the tree. Make sure you use stainless steel screws. Copper or brass will poison the tree.

Never wrap the tree or branch with rigid hard-plastic wire ties. Left unattended, these will result in death to the branch or to the whole tree. If wrapping the tree is the only option, use soft, rubber, UV resistant ties. These are very elastic and will give and stretch as the tree grows.

Hangar-bolts, sometimes referred to as "stand-offs", work very well to attach fixtures to trees. The hangar-bolts are screwed into the tree. A nut is put into place on the bolt about an inch out from the tree. The fixture is then placed on the bolt. Another nut on the bolt secures the fixture about an inch out from the tree itself. Depending on the growth rate of the tree, this may give 12-14 months between regular maintenance schedules.

General Procedures for All Installations

1. Determine proper location
2. Install desired lamp using a compound to prevent socket corrosion.
3. Assemble fixtures per manufacturer instructions.
4. Make all cable connections to all fixtures on one run and before finalizing connections, test lamp and check voltage. Remember to record your voltage on the As-built. Make adjustments as needed and finalize connections.
5. Perform final adjust of all fixtures at night.

WELL FIXTURES

Fixtures with a gimble ring or similar adjusting mechanism in an ABS or similar sleeve open at both ends.

1. Assess soil conditions and observe area for obstructions such as sprinklers, plant material, etc.

2. Dig hole 12” deep by 3” wider than well light.
3. Place minimum of 5” of pea gravel in the hole for drainage.
4. Place fixture at final height leaving 1 to 2 inches of the fixture above grade to minimize debris collection except in lawn areas where they should be flush with grade.
5. Allow enough slack in cable to be left inside well light for lamp removal (approx. 8-10 inches).
6. Backfill fixture properly compacting soil and securing fixture.

IN-GROUND FIXTURES

A fixture similar to a well fixture except that it is sealed on the bottom and has a lensed top.

1. Same procedures as well fixtures except no pea gravel is necessary.

TREE FIXTURES

1. Assess height of fixture location in tree. When above six foot on ladder tie harness to tree.
2. Hand trench at base of tree to minimize damage to tree roots.
3. Have all needed hardware and fixture on person.
4. Use conduit at base of tree to prevent damage from weed trimmers where applicable.
5. Attach fixture to tree using approved hardware and methods.
6. Note were cable will be seen from least and use that side of tree from fixture to ground to attach cable. Using zip ties with screw holes and 3” screws attach cable to tree. Leave zip tie slightly loose around cable to allow cable to move with the tree in the wind. (Be sure to trim excess tag from zip tie.)

PATH, SPOT, AND STAKED UPLIGHTS

1. Choose proper stake length for soil and fixture height/weight.
2. Install path fixtures far enough off walks and drives to prevent damage from contact.
3. Bury three feet of cable at base of fixture for possible relocation.
4. Backfill around stake and compact soil firmly; stabilize fixture keeping fixture plumb.

OVERVIEW

- Locate 120-volt power source for transformer. Remember to use the 120-volt receptacles on the front and back porches with discretion. These receptacles are for temporary usage. Most of your clients will not want a transformer mounted right in the flow of traffic.

- You might possibly have to contract with an electrician to set a dedicated circuit in a centralized location. Always make sure when installing an exterior 120-volt receptacle, you integrate a GFCI protected outlet.

- Be certain potential mounting surface can handle the weight and general size of the transformer. The transformer also needs to be mounted securely and the <u>bottom of the transformer must be at least 12 inches above grade</u>.

- Always use an approved weatherproof, 120-volt receptacle cover where your transformers are plugged in. Incorporate a drip-loop in the power cord when running it to the receptacle. That is, create a loop that drops down below the bottom of the transformers where the cord exits and below the 120-volt receptacle. When it rains or when the sprinklers come on, water hits the power cord and runs down to the lowest point and drips off onto the ground. This eliminates the possibility of the water running down the cord and into the 120-volt receptacle causing the GFCI to trip or into the transformer causing irreparable damage.

- Run your cables exiting your transformer through conduit and down into the ground creating a nice, neat professional installation.

- Typically it is best if wire runs don't travel out straight through flower beds and lawn areas. Follow the hardscape, curbs, flowerbed borders, sidewalks, driveways, foundation edges, etc.

- When mounting fixtures to trees, there are four issues to be concerned with: Safety of the installer, securing the wire to the tree, attaching the fixture to the tree, and future maintenance.

- Always engineer your design in such a manner so you are using #12 cable or smaller up in a tree. Never use copper or brass attachments, as these will slowly kill the tree. Most importantly, always plan to maintain whatever you do!

- Hangar bolts are a successful way to attach fixtures to trees. Screw the wood screw end of the hangar bolt into the tree and attach the fixture to the machined bolt end of the hangar bolt and secure with a nut and lock washer. When completed, the distance between the secured fixture and the tree may be up to 1". On most trees, 1" of clearance may be up to 9 to 12 months before the nut must loosened and the fixture backed out to increase the fixture/tree clearance.

- When making the electrical connection up in the tree, a two-conductor "trailer-type" connector can make maintenance easier. Attach one end of the connector to the cable feeding the fixture and the other end to the fixture leads and just simply "snap" the connector together, conceal it behind the fixture and the process is complete. Now, when the lamp does burn out, just "pull apart" the connector, take the fixture to the ground, change the lamp and re-install in its original location and position. Snap connectors are not the only way to go in trees. If you have a fixture that can be safely re-lamped in the tree a permanent connection can be used.

- When running cable under driveways, sidewalks, patios, or other obstacles, always run an extra cable through or, use large enough conduit that has room for more wire. Without a doubt, this will save countless hours of work, thus resulting in extra profit. Plan for expansion at all times. Even if you feel the client could never expand what you've designed and installed, plan for expansion. It will pay off some time in the future.

- Make your direct-burial connections as though your life depends on it. If anything can go wrong, it will undoubtedly happen to a splice, as it is the weakest link. There are many systems available today. There are gel-filled wire-nuts, silicone filled oversized wire-nuts, brass-barrel connectors that are shrouded with a specially designed heat-shrink material. Whatever device you choose to use, it must fit the following criteria:

  a. Good metal to metal contact
  b. Extremely tight
  c. Completely waterproof
  d. Sized properly
  e. Have proper volt / amp rating

  Remember, when using connectors and sealing compounds not all compounds are the same. An acceptable sealer must bond to the connector and wire jacket.

- When installing ground-mounted fixtures, leave an extra 2'-3' of cable at the base of each fixture in a coil and bury it. When the plant materials mature and the fixture needs relocating, it's very easy to accomplish with the extra cable already attached. With adjustable height pathlights extra wire should be left in the fixture to allow for height adjustment.

- Spray an oil base rust inhibitor or silicone electrical spray on the twisted cables just before inserting them into the transformer terminal blocks. This will keep corrosion from occurring and ensure a sound connection. This step should be repeated during regularly scheduled maintenance visits.

- When lighting immature trees that may only need a single fixture provide at least one unused cable run for future additional lighting.

Chapter 6
Installation Records

As Built Drawings

If working from an existing landscape plan then use a clean copy of the plan to lay out the location of sleeves, wire runs, power sources, fixtures, transformers, and any other equipment relative to the lighting installation. If a landscape plan is not available then a site plan or a hand drawn property plan, or similar, not to scale, shall be used instead.

Keep the as-built as part of the record of the project for at least three years. The as-built is especially useful for future maintenance or expansion of the system. Additionally you would want to have record of the following:

TRANSFORMER DATA –

1. Mounting location
2. Manufacturer name
3. Date of installation / Installing technician
4. Warranty period
5. Total wattage load
6. Transformer service area
7. Transformer controls, control model / warranty / location:
    a. Photocell
    b. Electronic switches
    b. Timer
    d. Motion detectors
    e. Other
8. Timer programming
9. Switch codes and/or settings
10. Power source information
    a. Plug-in GFCI outlet
    b. Dedicated circuit
    c. Shared circuit
    d. Electrical panel location
    e. Breaker number
    f. Breaker amperage

Chapter 7

Troubleshooting Overview

Equipment

1. Multi-meter - Measures voltage (to .01), amps, resistance (OHMS), and continuity.
2. Wire Locator - Traces wire paths
3. Pulsar - Locates wire faults
4. Toner \ Inductive Amplifier - Identifies which fixtures are on which run
5. Test Fuse-Stat - Eliminates wasteful burning of permanent fuse-stats

These items are a must for those who wish to troubleshoot and repair lighting systems quickly and easily without guess work and unnecessary digging. However, should these items not be available to you the following procedures will allow you to troubleshoot and repair lighting systems.

Most of the time, the problem is right before our very own eyes. Look for the obvious and the solution will usually turn out to be a very simple one.

Always break the system down into components (sections), start at the source of power and work your way out into the system basing your moves on the process of elimination.

Some of the more obvious reasons why the landscape lighting system will not operate are:

- 120-volt power source is off, disconnected, or tripped breaker/GFCI
- 120-volt source is on a switched receptacle and the switch is in the off position.
- Transformer has an on/off switch and is in the off position.
- If unit has a built-in timer, the timer is in off position.
- If unit has a built-in photocell, the photocell is receiving light and is therefore in the off setting.
- Transformer has a built-in secondary or primary fusing device that has blown due to system problem.
- The cables leading from the transformer out into the landscape have been cut.
- The cables entering the transformer cabinet are wired incorrectly.

Entire System Failure

1. Check 120-volt AC socket with volt-ohm meter that is set for 120-volts AC.

    a. Check and make sure breaker is on in the service panel and if the outlet is GFCI protected, check the reset button and ensure it is set.
    b. If there is a problem with the 120-volt call an electrician.

2. Check to see if the transformer has an on/off switch inside the cabinet and make sure it is in the on position. Also make sure the toggle-switch is in the correct position.

3. Check that the secondary fusing device in the transformer is not blown or tripped.
   If the secondary fusing device has tripped or has blown reset/replace and test the system. To test the output of the transformer take a volt-ohm meter set to AC and touch the wires/probes to the volt output terminal blocks or wire leads and determine if there is or is no output.