National Electrical Code Requirements for In-Roadway Lights

The Millennium Edition of the MUTCD, Section 4L.01 has the requirements for In-Roadway Lights (IRL). This type of warning light is installed in the roadway and is typically used for marked crosswalks. The MUTCD sets the maximum height of 19mm (0.75 in) above the roadway surface, and has the requirements for flash rate and actuation method. However the electrical installation method is up to the agency or Authority Having Jurisdiction (AHJ). The electrical supply can be in conduit, direct burial, or a pavement saw cut, depending on the type of IRL. Obviously, being able to install the supply conductors in a saw cut is much less expensive than having to cut the roadway and install conduit. This article will review the various types of IRL systems and attempt to correlate them to NEC requirements.

Types of In-Roadway Lights
There are numerous types of IRL systems, each with different types of lights, power supply and installation requirements. The three basic types are series, parallel and inductive. Many of the IRL systems are unique to a specific manufacturer.

- **Series AC**
  Operation: Lamps wired in series (same as an airport runway lighting system). This equalizes the voltage to each fixture and eliminates voltage drop concerns.
  Lamp type: Halogen ruggedized airport, 6.6 amp, 7 volts, 50 watts
  System voltage: 7 volts per fixture x number of fixtures
  Lamp life: 3 years
  Conductor: 10 AWG
  Typical Installation: RMC or PVC conduit between fixtures
  System voltage is designed for number of lamps, example a six light system has a operating voltage of 42
  Each fixture has a bypass in case a lamp goes out
  Due to the high brightness of one manufacturers system, it is dimmed by 20% at night

- **Parallel Low Voltage DC**
  Operation: Parallel, voltage is increased to compensate for voltage drop
  Lamp: high Intensity LED, 1.2 watts
  System Voltage: 6 to 32 Vdc
  Lamp life: About ten years
  Conductor: 16 or 14 AWG, depending on length
  Typical installation: Saw cut or conduit, uses a drop in can or a cored hole

- **Parallel Low Voltage DC**
  Operation: Parallel
  Lamp Type: High Intensity LED, 2 Watts, 13.5 VDC
  System Voltage: 13.5 VDC

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1 LED lamp life is hard to predict. It is greatly affected by temperature. Installation in the roadway is the worst possible environment.
Lamp Life: About ten years
Conductor: 14 AWG USE XLP
Typical installation: Saw cut

- **Inductive Powered, Low Voltage High Frequency**
  Operation: LED lamps are inductively powered from a buried cable. Shuts off power if cable is cut. System increases power to compensate for voltage drop. Operates at 38.4 kHz.
  Lamp: High Intensity LED, voltage  depends on length of cable, typically is 20 volts for a 24 head installation, 1 amp for 24 head installation
  Lamp life: About ten years
  Conductor: 8 AWG parallel flat figure 8 cable
  Typical installation: Saw cut, using a 2 conductor cable. A node is installed over the cable, and the node/cable assembly is sealed. The inductive heads are epoxyed over the nodes.

**What are the NEC Requirements for Installation?**
IRL is a relatively new product, and agencies or the AHJ may not know what NEC requirements. Normally, the NEC requirements for a product are determined by its listing/labeling, it is installed per the instructions and the applicable NEC Article. There are a number of articles in the NEC that can lead to some basic rules for installing IRL.

For example, Article 411 is *Lighting Systems Operating at 30 Volts or Less*. The scope of Article 411 covers lighting systems operating at 30 volts or less and their associated components. This type of lighting system is typically used for under cabinet and landscape lighting. Conductors may be a 16 AWG parallel flat cable, and outdoor installations can be made with the cable laid on the surface of the ground, as there is little shock hazard.

411.2 Definition.
*Lighting Systems Operating at 30 Volts or Less*. A lighting system consisting of an isolating power supply operating at 30 volts (42.4 volts peak) or less, under any load condition, with one or more secondary circuits, each limited to 25 amperes maximum, supplying luminaires (lighting fixtures) and associated equipment identified for the use.

It’s important to note Article 411 applies to listed lighting systems, meaning a product designed for that purpose, not one assembled by the user from various components. While Article 411 may not apply to IRL, the 30 volt or less is an important limitation set by the NEC in general, as below 30 volts AC is generally not considered to be a shock hazard.

**Grounding**
Safety grounding establishes a low impedance path to the source to remove dangerous voltage due to a ground fault, to prevent shocks and fires. The rules for grounding are covered in NEC Article 250. Section 250.20 lists the AC circuits that are required to be grounded.
250.20 Alternating-Current Circuits and Systems to Be Grounded.
(A) Alternating-Current Circuits of Less Than 50 Volts. Alternating-current circuits of less than 50 volts shall be grounded under any of the following conditions:
(1) Where supplied by transformers, if the transformer supply system exceeds 150 volts to ground
(2) Where supplied by transformers, if the transformer supply system is ungrounded
(3) Where installed as overhead conductors outside of buildings

AC circuits operating below less than 50 volts are not required to be grounded, except as given above in (1), (2) or (3).

In Article 720 Circuits and Equipment Operation at Less Than 50 Volts, Section 720.1, Scope states This article covers installations operation at less than 50 volts, direct current or alternating current. Section 720.10 refers to Article 250 for grounding requirements.

Article 725 does not require grounding for circuits operating at less than 50 volts per Section 250 112.(I). Generally, grounding is not required for circuits operating at less than 50 VAC. There are exceptions, for example: hazardous locations or patient care receptacles. Also, if the IRL lamp circuit was subject to being energized by a higher voltage than grounding may be required. Locations subject to lighting may require grounding.

**Shock Hazard**
The NEC contains many references to voltages below 30 VAC being considered safe from contact. For example: Article 620 Elevators, Dumbwaiters, Escalators, Moving Walks, Wheelchair Lifts, and Stairway Chair Lifts do not require working clearance for low voltage circuits.

620.5 Working Clearances.
(D) Low Voltage. Uninsulated parts are at a voltage not greater than 30 volts rms, 42 volts peak, or 60 volts dc.

Any voltage can be considered dangerous, given the right conditions, but generally circuits under 30 VAC RMS and 60 VDC are safe, and IRL using these voltages or less may be suitable for direct burial or sawcut applications.

**Article 725 Class 1, Class 2, and Class 3 Remote-Control, Signaling, and Power-Limited Circuits**
This article can be thought of as “The Mother of All Low Voltage Articles” and may be the most appropriate article for low voltage IRL. The appropriate systems would be:

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2 For an excellent review of Low Voltage requirements, a free download Mike Holts 34 page Low Voltage and Limited Energy Systems is available at [http://www.mikeholt.com/low/low.htm](http://www.mikeholt.com/low/low.htm). Although based on the 1999 NEC, the code rules are essentially the same for the 2002 NEC.
Typical Class 2 circuits are thermostat, local area computer networks, and doorbells. Note as the voltage increases the power limit is decreased.

Class 3 Circuit: Inherently limited: 31 to 100 volts, 100 VA
  Not inherently limited: 31 to 150 volts, 100 VA
A Class 3 circuit has higher voltage and power limits than Class 2, and the NEC has additional requirements for safety, as a Class 3 circuit can be up to 100 volts, a dangerous voltage.

A class 2 or 3 circuit does not require conduit for conductor protection.

Other Than Low Voltage Lighting
If a IRL system is determined to be other than low voltage, then the NEC rules for power and lighting branch circuits would apply, in other words the system would be installed much as a standard roadway lighting system, per Article 240-Overcurrent Protection and Chapter 3-Wiring Methods and Materials.

Determining NEC Requirements:
Review the following operating characteristics of the system to determine the applicable NEC requirements:
- Secondary voltage, amperage, and wattage
- Power Supply fusing or limiting
- If a saw cut application, what would happen if there was a current leakage to ground? Would the power supply limit the output?
- For a saw cut application, is there danger that a metal object could contact the lamp supply conductors and pose a shock hazard?

Maintainability
Obviously an IRL system has to have the lamps replaced. The type of lamp housing, lamp life and accessibility should be evaluated.

Summary-In general:
- Circuits operating at less than 30 VAC rms and 60 VDC have a reduced shock hazard
- Circuits operating at less than 50 VAC or VDC do not normally require safety grounding
- Circuits exposed to lighting (run overhead) require safety grounding
- Circuits operated from a supply exceeding 150 volts to ground require safety grounding
- Circuits supplied from an ungrounded supply require safety grounding.
- The usual separation requirements for low voltage conductors apply (low voltage conductors can not occupy the same enclosure, box or raceway with power (120
VAC) conductors even if insulated for the maximum circuit voltage (See FPN to 300.3(C)(1) and Section 90.3)

The installer, manufacturer and AHJ will determine the installation requirements. Consideration has to be given to shock hazard, public safety, and maintenance requirements. The most conservative installation would be rigid metal conduit, with a minimum cover depth of 24” per Table 300.5, and a equipment grounding conductor sized per NEC Section 250.122. PVC conduit can be used, but if exposed to physical damage it must be Schedule 80 per the UL Listing. An alternative would be to concrete encase the PVC conduit.

**Inspection and Code Compliance**

There are many installations of IRL where the AHJ has required a field evaluation from a testing laboratory, such as UL, prior to approval of the equipment and installation. A field evaluation can be expensive and delay the project, however the AHJ has the responsibility for approval of equipment per NEC Section 90.4, 1st paragraph.

**90.4 Enforcement.**

*The authority having jurisdiction for enforcement of the Code has the responsibility for making interpretations of the rules, for deciding on the approval of equipment and materials, and for granting the special permission contemplated in a number of the rules.*

As these products are not listed by a testing agency, the AHJ may not allow the installation. The AHJ can only allow approved products per NEC Section 110.2.

Section 110.3 lists the requirements the AHJ uses for evaluation of equipment.

**110.3 Examination, Identification, Installation, and Use of Equipment.**

(A) Examination. In judging equipment, considerations such as the following shall be evaluated:

(1) Suitability for installation and use in conformity with the provisions of this Code

*FPN: Suitability of equipment use may be identified by a description marked on or provided with a product to identify the suitability of the product for a specific purpose, environment, or application. Suitability of equipment may be evidenced by listing or labeling.*

The AHJ has the authority to waive specific requirements per 90.4, 2nd paragraph.

**90.4 Enforcement.**

*By special permission, the authority having jurisdiction may waive specific requirements in this Code or permit alternative methods where it is assured that equivalent objectives can be achieved by establishing and maintaining effective safety.*

The AHJ can allow exceptions, but the Article 100 definition of Special Permission requires this to be granted in writing. If a manufacturer was to offer a listed IRL, it would simplify installation by providing an installation procedure, and the listing would assure
the AHJ the product is safe. Such listing may provide a market edge. A field evaluation from a testing labority can cost $1,500 or more.

**Summary**

If a traffic signal heads uses an incandescent lamp, any manufacturer's lamp will work in any manufacturer's fixture. IRL must be considered as a system and installed per the manufacturer's instructions. If you are installing an IRL for the first time, after you select the system, review the installation with your manufacturer and if a permit and inspection is required, review it with your AHJ. The NEC installation requirements are dependant upon the luminare circuit supply voltage and ampacity. If this is the first application for your agency, consider getting approval from the AHJ first. Remember a change in the 2002 NEC requires special permission to be given in writing.

**Authors Note**

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This article should not be considered the final word on NEC requirements for IRL. If you have any comments or installation suggestions please mail me and I’ll do a follow up article later. If there is a manufacturer of an different IRL system please email me contact information for further follow-up. From reviewing the various systems, all the information needed to determine the installation is not always readily available, or may not have the appropriate information to determine NEC requirements.