USSC **FOUNDATION**

LED Handbook

LED SIGN LIGHTING

USSCF ON-PREMISE SIGNS / RESEARCH SUMMARY

LED Handbook
Sign Lighting

A Project Of The
USSC FOUNDATION

By
Randall K. Wright

RKW Consulting
698 Walnut Street
Montoursville, PA 17754

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For further information concerning the
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contact:

215-785-1922
www.usscfoundation.org
usscfoundation@usscfoundation.org

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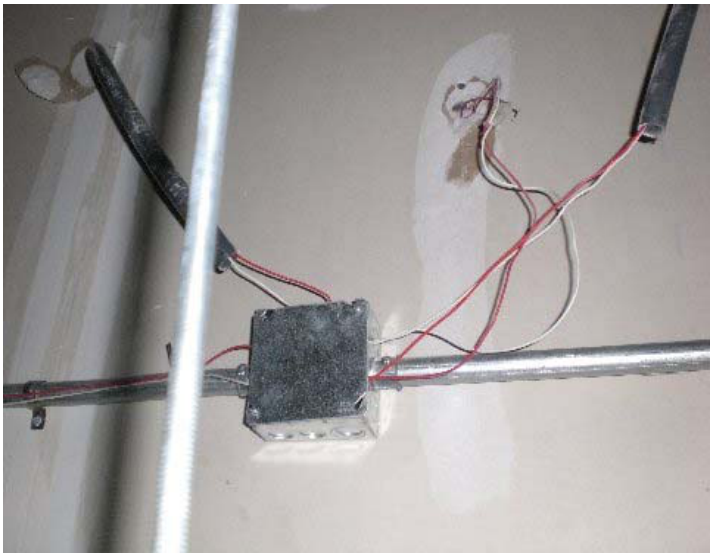
Section I: The LED.

Section II: The LEDS Rules for Listing.

Section III: The LEDS Rules for Installation.



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The LED:

The sign industry is currently using LED light sources for many applications. As LEDS where first introduced to the sign industry I believe it was on the power source equipment as indicators for conditions and problems.

As the LEDS became used in different applications such as tail lights for vehicles, traffic control, warning lights as well as indicator lights, their applications expanded.

The first and most significant piece of information is that all LED'S are not created equal.

The LED we use is a P-N junction semiconductor diode which emits an incoherent narrow-spectrum monochromatic (single color) light when voltage is applied in a forward direction. Now, if that definition doesn't scare you lets move on.

The original LED was born. Since then many different compounds and processes have been added and have currently created the blue LED which allows us the have White light.

Picture complements of Wikipedia Encyclopedia

This information is all readily available on the internet and is not the purpose of the article. A complete list and more expert explanation can be found at http://en.wikipedia.org/wiki/LED

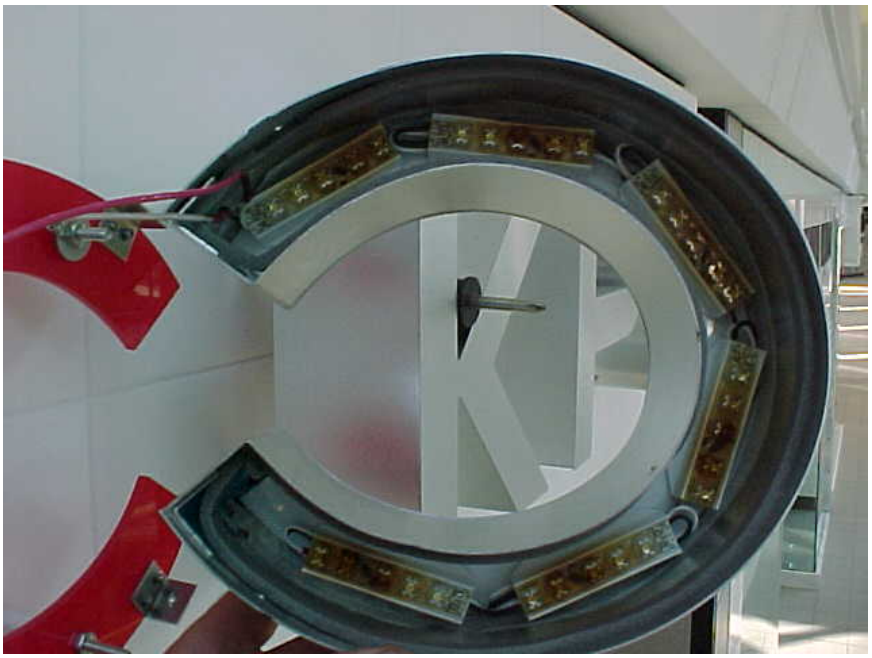
The reason for the chemistry lesson is only to impress how important it is to select and work with a quality LED manufacturer/supplier. LEDS today, although more refined, are still made in batches and there can be as many as four different hues of a color in each batch.

The batch is then separated into"bins" usually four. When using white your must be very careful in selecting the same or similar bins to insure similar color output. I would also recommend you do your homework in selecting a company which can provide an adequate amount of the same (lot number – batch and bin) type of LEDS to complete your project with some spare units, for future service.

Also choose the company with the system that fits your manufacturing style, products and capabilities.

The LED manufacturer/suppliers also control brightness by the current to the LEDS by their power supply and wiring methods (series-parallel). More power means brighter, hotter and reduced life for the LED.

Heat produced by the led will become its reason for failure. This can happen rather quickly when the LEDS are driven with too much current. When are installed in and area where the ambient temperature is too high for their duty cycles; or heat sinking is not done.



While the original red color was able to be pumped up enough to be used either exposed or behind plastic for use in channel letters and quickly became a competitor to the neon tube.

The light source is low voltage and perceived safe from arcing and fire. The installation procedure is perceived to be simple compared to the complex installation of the high voltage requirements of neon installations.

Now since the natural color LEDS are at 1 watt and soon higher, different considerations will be needed, because of the increased heat levels.

Since LEDS provide only directional light, the applications become a little more difficult to design since you do not have the same benefit of light bounce that neon and fluorescent has to offer.

Your LED partner should be able to direct you in the correct installation and configuration procedures to provide the best lumen output and direction to meet the application.

My original intention was to create a standard or rule of thumb that we could use, as we do with neon, to build our LED channel letters. I was quick to find that there are way too many different applications that prevent us from accomplishing this task.

Since we only deal with listed electric signs, we must remember, we can only use listed and recognized components to build our electric signs and channel letters. Listed sign manufacturers have access to the UL SAM manual updated August 2008 that has over 80 plus products for use, as or in LED applications.

The Led Rules for listing:

The National Electric Code NFPA 70 requires listing on electric signs. (NEC 600.3)

600.3 Listing. Electric signs, section signs, and outline lighting – fixed, mobile, or portable – shall be listed and installed in conformance with that listing, unless otherwise approved by special permission.

Electrical Inspector Question: When inspecting an electric sign illuminated with LEDS do you require it to be listed?

Answer: Yes (600.3). Listing serves as a basis for inspector's approvals.

I feel the manufacturers who helped me with information, can provide you with all the technical information, product and support to manufacture a quality listed electric sign.

When selecting your LED partner look at all the parts and pieces needed to complete the entire listed product; don't try to mix and match parts and pieces. Also make sure you outline the type of letters and letter materials you will be using.

Newer higher powered LEDS have some increased heat to be dealt with and the LED partner can help you with controlling the additional heat if required.

The components are controlled in UL 879 8th addition, with an effective date of September 2008, currently Section 4.18 Class 2 LED components. The section currently has 14 different sections with requirements. Please review all the sections before you start your manufacturing. These sections relate to the conditions of acceptability. The conditions of acceptability for a component, is every bit as important as bonding and grounding. The parts used in building listed electric signs have conditions of acceptability which need to be met when used in different applications. This is the way the part can be used based on its intended application.

UL Question: Do you require the listed and recognized sign component manufacturers to provide the sign manufacturers with installation instructions for their components?

Answer: Yes

UL Question: Does UL review the installation instructions as part of the recognition or listing of the product.

Answer: Yes, UL reviews the installation instructions provided by sign component manufacturers and for installation instructions for Section Signs in accordance with the requirements in Par. 41.1.1 of UL 48.

I have reprinted the requirements for installation instructions for the components below with permission from Underwriter Laboratories, Inc.

4.18.4 Installation Instructions

4.18.4.1 LED units shall be provided with installation instructions that include the following:

a) A location designation indicating the environmental condition for which the product has been evaluated (e.g. wet, damp, or dry location);

b) These products are only suitable for connection to a circuit from a Class 2 power source;

c) These products have not been evaluated for use when connected to a power source that does not comply with Class 2 voltage and energy limited supplies; and

d) For wet location products, "These products are not required to be enclosed or protected from weather".

Some of the most important items in the standard relate to only being allowed to be connected to class 2 power supplies (30 volts or less), special requirements for wet locations. (See note 2 reprinted from UL 879)

NOTE 2 For nonsinusoidal ac, Vmax shall not be greater than 42.4 volts peak. Where wet contact (immersion not included) is likely to occur,Class 3 wiring methods shall be used or Vmax shall not be greater than 15 volts for sinusoidal ac and 21.2 volts peak for nonsinusoidal ac.

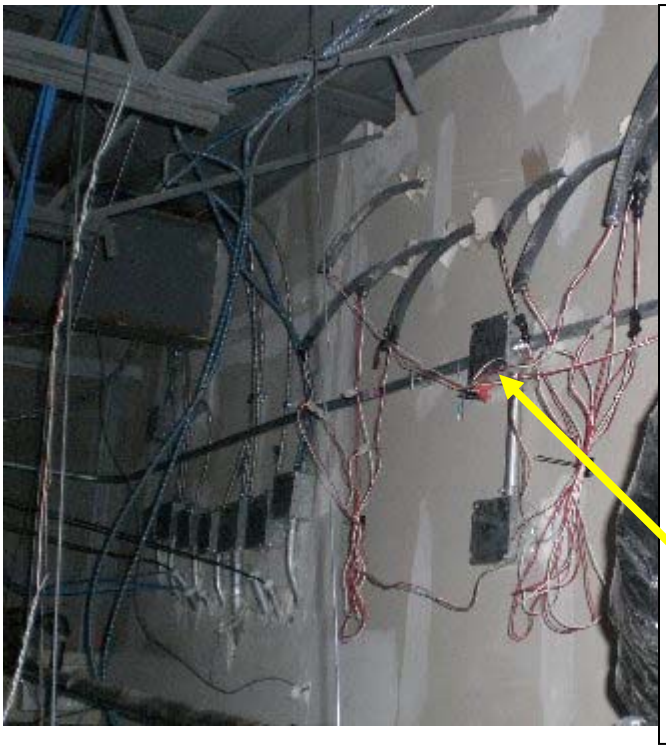
The importance of these instructions is to insure you use the components with the correct **conditions of acceptability** in your listed electric sign. Each component manufacturer should have mounting, electrical, heat sink, and directional information for your use either printed, in the shipping containers, or on their web site for your use.

The Led Rules for Installation:

Secondary wiring is also a point of confusion. When wiring is run exposed it must be PLTC (power limited tray cable) type or enclosed. The wire shall be furnished as required with the power supply and should have a means for connection to the LEDS supplied.

The field wiring methods shall be connected in accordance with the National Electric Code NFPA 70.

4.18.2.3 LED Displays shall be provided with the means to connect to a Class 2 power source by Class 2 wiring methods in accordance with the National Electrical Code NFPA 70.



NEC 2005 Violations:
110.3(B) Installation and Use
110.12 Execution of workmanship
250.112 (G)&(I) Grounding
300.4 Protection from Damage
336.12 PLTC Cable
600.3 Listing
600.7 Grounding
600.24 Class two power sources
725.8 mechanical execution of work
725.41 class two wiring
(Above references are explained in the text or available in your code book)

The power supplies are mounted in the rear of the store and all the secondary wires are run in these conduits and connected and secured under the covers of the junction boxes (installation instructions would never allow this)

Equipment grounding does not exist beyond the original conduit.

UL Question: Is the secondary wiring on a led sign part of the required installation instructions?

Answer: The installation instructions should provide guidance on wiring the LED sign including wiring to remote sections of an LED section sign.

Electrical Inspector Question: Do you feel this was done on conformance with the NEC and would you approve it just because it is low voltage?

Answer: No (violations too numerous to enumerate). This installation looks like it was performed by unqualified persons?

The power supply on permanently connected signs is required to be enclosed.

4.18.5.2 Power supplies and transformers shall be enclosed in an electrical enclosure.

Section Signs: UL 48 Requirements for Installation Instructions (UL48 41.1)

a. Drawing of subassemblies arrangement

b. Instructions for the physical installation and mechanical connection of the subassemblies

c. Wiring arrangement of the subassemblies and components necessary to complete the electrical connenction

d. Conditions of use required for subassemblies.

e. Conditions of use for components required to complete the wiring

f. Instructions for the field wiring between the subassemblies and components and connection to power source.

II. Typical Installation Instructions: Section Letter Sign: LEDs

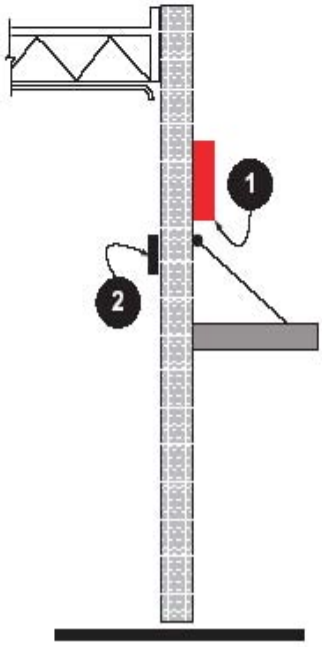
1 of 3

UL 48 41.1.1 (a) Drawing of Subassemblies Arrangement

TOTAL SUBASSEMBLIES: 9

1. Section Letter Sign. 24 Inch Pan Channel Letters / 5 Inch Returns Red Acrylic Faces / LED Recognized Component Illumination system. (Component manufacturers name and catalog designation). (6 Subassemblies)

2. LED Class 2 power supply. (3 Subassemblies)



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II. Typical Installation Instructions: Section Letter Sign: LEDs

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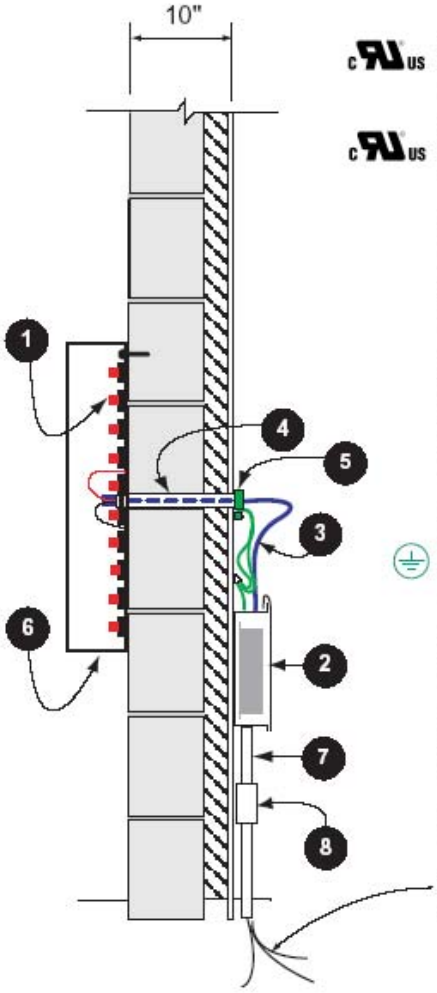
UL48 41.1.1 (b) Instructions for the physical installation and mechanical connection of subassemblies.
UL48 41.1.1 (d) Conditions of use for subassemblies
UL48 41.1.1 (e) Conditions of use for components required to complete wiring*



1. Recognized Component* LED. Class 2 Illumination System LED Modules Suitable for wet or dry location. Factory wired. (Name of component mfg.)

2. Recognized Component* Class 2 Power Supply in 24 ga sheet metal enclosure. Power supply factory installed in enclosure. Secure enclosure to wall surface with four (4) wall board fasteners

3. Type PLC cable* rated for use without conduit in damp or dry location. Connect power supply output leads with insulated compression wire connectors to matching color of free conductors in section letter. Bundle neatly and secure to wall with plastic cable ties within 12" of conduit and enclosure and at 6' intervals.

4. Drill 1" dia holes through cement block facia, perpendicular to wall at locations shown on full size installation pattern. Secure 1/2" running thread to metal letter back. Remove paint from metal at point of connection to conduit. Double lock-nut, wrench tight. Insert 1/2" running thread through holes in wall. Apply silacone sealant around conduit and hole in cement block before fitting the letter back flush with wall surface.

5. Thread grounding bushing onto 1/2" running thread conduit. Attach No. 14 bonding jumper to each bushing (6) and to one power supply enclosure. Bond enclosures to branch circuit equipment ground.

6. Channel letter subassembly sign body suitable for wet location. One 1/4" drain hole in low points of each letter. Attach metal letter back to building facia with 1/4" concrete fasteners at predrilled locations in letter back.

7. No. 14 MC Cable between power supply enclosures and disconnect. Secure to wall with cable ties, within twelve (12") inches of termination at enclosure and at no less than at six foot (6') intervals.

8. Safety Switch / Single Pole / Dry location. Firmly secure in place with wallboard fastners.

Branch circuit conductors of suitable capacity and approved type to section sign by others. (120 V / 20 AMP / 792 VA)

***(e) COPY OF MANUFACTURERS CONDITIONS OF USE FOR EACH COMPONENT ATTACHED AND INCLUDED AS PART OF INSTALLATION INSTRUCTIONS.**

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Some of the more confused and abused areas in the electric sign industry are the installation of these signs and section letter signs. The NEC National Electric Code will govern the completion of the installation in the field. (Connecting the sub-assemblies together) The electrical inspector will be looking for the installation instructions to be used as a guide on how the sub-assemblies are to be connected, and will review the primary connections for his or her approval.

ARTICLE 600
Electric Signs and Outline Lighting

600.3 Listing. Electric signs, section signs, and outline lighting – fixed, mobile, or portable – shall be listed and installed in conformance with that listing, unless otherwise approved by special permission.

Electrical Inspector Question: Would you give your written approval of special permission to an unlisted electric sign?

Answer: Yes, but only if conformance with all applicable standards and the NEC could be verified and the Jurisdiction's administrative procedures for issuing special permission were adhered to.

Now that we have manufactured these letters it is time to install them. Some of the more frequently asked question is since these letters are class two do they require Grounding? The short answer is yes.

Grounding as defined by me: Continuous connection by bonding of all dead metal parts from the sign system to the equipment grounding conductor as supplied by the building's electrical service. The system must be capable of handling any fault current imposed on the system.

Electrical Inspector Question: Would you approve a listed electric led sign that was not connected to the equipment grounding conductor?

Answer: No. Grounding is required per 600.7.

Now, what you may be told is class two power 30 volts or less is considered safe from a fire initiation standpoint and provides acceptable protection from electric shock. This is stated in article 725 of the NEC.

The code, maybe confusing to some, is arranged so the first four chapters apply to all electrical utilization equipment. Article 250 (250.112 (G) (I) signs and power limited must be grounded) Now article 600 can modify or amend article 250 but 600.7 or 600.24 does not exempt signs or class two power limited from equipment grounding.

250.112 Fastened in Place or Connected by Permanent Wiring Methods (Fixed) – Specific. Exposed, non-current carrying metal parts of the kinds of equipment described in 250.112(A) through (K), and non-current-carrying metal parts of equipment and enclosures described in 250.112(L) and (M), shall be grounded regardless of voltage.

(G) Electric Signs. Electric signs, outline lighting, and associated equipment as provided in Article 600.

(I) Power-Limited Remote-Control, Signaling, and Fire Alarm Circuits. Equipment supplied by Class 1 power limited circuits and Class 1, Class 2, and Class 3 remote control and signaling circuits, and by fire alarm circuits, shall be grounded where system grounding is required by Part II or Part VIII of this article.

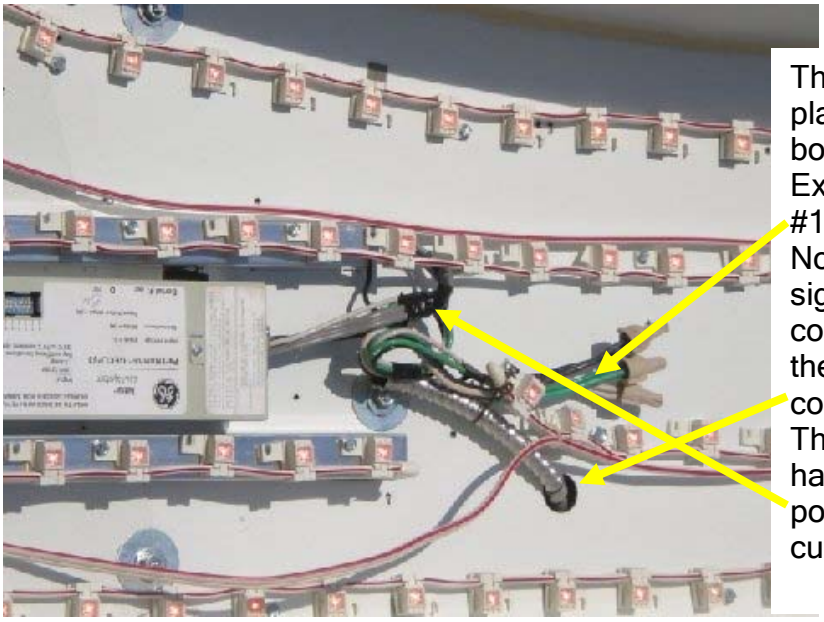
600.7 Grounding. Signs and metal equipment of outline lighting systems shall be grounded.

Therefore electric signs shall be grounded by continuous connection (bonding) to the equipment grounding conductor. The reason you don't find exceptions for this equipment, in my opinion, is the startle voltage present could still initiate a fall, other equipment may come in contact with the metal, and they are all driven and connected to power supplies using line (120va) voltage.

600.5 Branch Circuits.

(C) Wiring Methods. Wiring methods used to supply signs shall comply with 600.5(C)(1), (C)(2), and (C)(3).

(1) Supply. The wiring method used to supply signs and outline lighting systems shall terminate within a sign, an outline lighting system enclosure, a suitable box, or a conduit body.



This letter was made with a plastic face making it a sign body.
Exposed primary wiring violation #1
No approved connector on the sign letter where the flexible conduit should have connected the equipment grounding conductor violation #2
The conduit and primary should have extended all the way to the power supply as opposed to cutting off the plug, violation #3

UL Question: How would no provisions for a primary connection and lack of suitable installation instructions get by the follow-up inspectors?

Answer: UL Field Services Representatives regularly audit representative production samples of signs built by sign manufacturers under the UL Listing and Follow Up Service for Signs to verify compliance with the UL Requirements for Signs as defined in UL 48 Standard for Electric Signs. However, UL Representatives do not normally inspect all outgoing production of the sign manufacturers.

600.24 Class 2 Power Sources. In addition to the requirements of Article 600, signs and outline lighting systems supplied by Class 2 transformers, power supplies, and power sources shall comply with 725.41
The reference to 725.41 directs the installer and the inspector to the secondary wiring methods and type of wire based on the application. Generally the most violated areas I see is not using the correct secondary wire. I get calls about landscape wire, lamp cord, lack of installation instructions for the electrical inspector and so on and on.

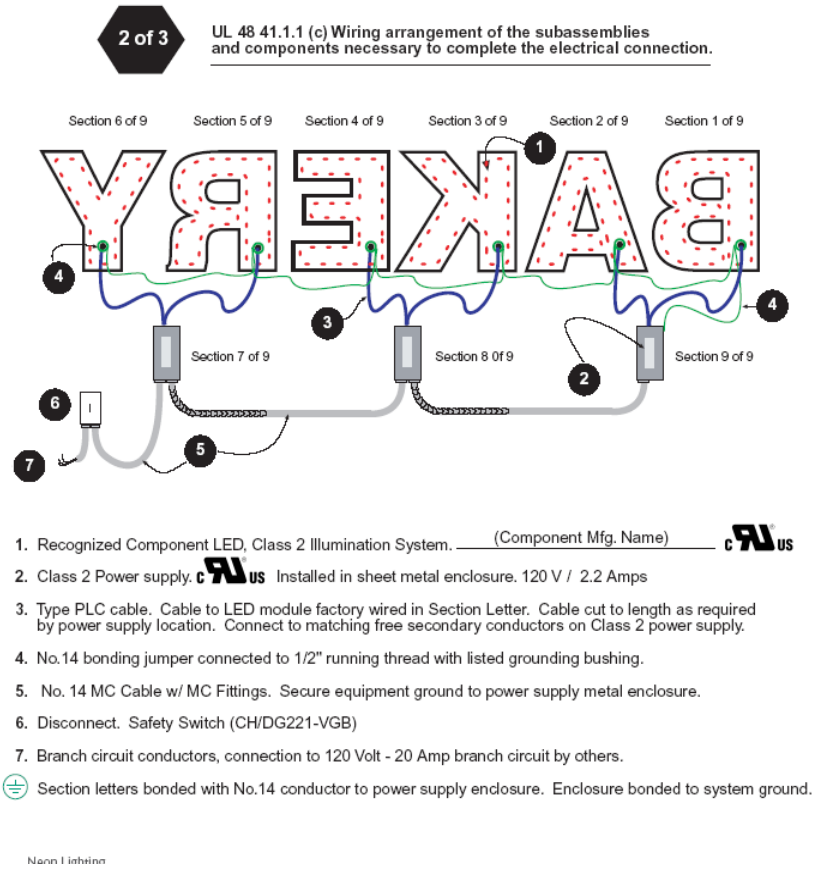
Chapter 3 Wiring Methods and Materials

I. General Requirements

300.1 Scope.
(A) All Wiring Installations. This article covers wiring methods for all wiring installations unless modified by other articles.

300.4 Protection Against Physical Damage. Where subject to physical damage, conductors shall be protected.

You installation instructions should be clear if you run conduits from your channel letters to your remote power supply enclosure you can use the CL (cheaper) wire inside the conduits and sign body. If you choose not to run conduits from your remote power supply enclosure to the channel letters you will need to run PLTC wire. (Power Control Tray Cable)



UL Question: Does UL evaluate the location of the wire and require a specific type when reviewing installation instructions for UL 879 or UL 48?

Answer: UL does review installation instructions to help ensure that proper guidance is provided in accordance with UL 48. Since installations are often unique, installation instructions provided with the signs provide general direction and guidance with regard to wiring. This may include guidance on the type and placement of wiring or may refer to the NEC for guidance on suitable types of wiring required or other applicable installation issues.

ARTICLE 336
Power and Control Tray Cable: Type TC

336.12 Uses Not Permitted. Type TC tray cable shall not be installed or used as follows:
(1) Installed where it will be exposed to physical damage
(2) Installed outside a raceway or cable tray system, except as permitted in 336.10(7)
(3) Used where exposed to direct rays of the sun, unless identified as sunlight resistant
(4) Direct buried, unless identified for such use

The reference to 336.10(7) is for industrial establishments and has qualified maintenance personnel doing the work.

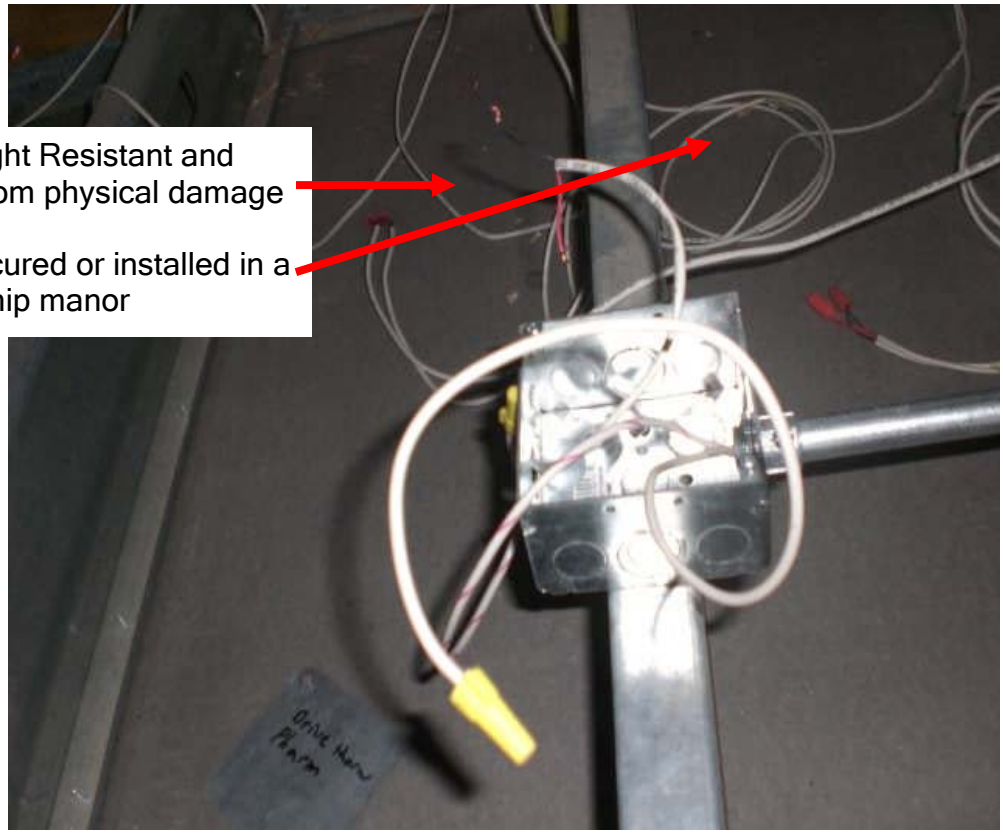
725.8 Mechanical Execution of Work. Class 1, Class 2, and Class 3 circuits shall be installed in a neat and workmanlike manner. Cables and conductors installed exposed on the surface of ceilings and sidewalls shall be supported by the building structure in such a manner that the cable will not be damaged by normal building use. Such cables shall be supported by straps, staples, hangers, or similar fittings designed and installed so as not to damage the cable. The installation shall also conform with 300.4(D)

This is the section where the modification to use class two is drawn and is clear about "ceilings and sidewalls" and supported as to not be damaged.

If you are purging walls, entering metal letters and other areas where the wire could be damaged you shall be required to protect it (the wire) from physical damage.

Electrical Inspector Question: Would you allow any of these conductors to be run exposed through walls or be exposed in a wet location?

Answer: Yes, if suitable for wet locations, properly secured, protected from physical damage and installed in a neat and workmanlike



The other concern is when using low voltage corrosion becomes a problem. Make sure all your connections are made with your LED partners connection devices or classified connectors for use in the correct environment. (Wet, Damp, Dry) There are commercially available connectors provided with sealant for use in these applications.

In review:

- LED components need to be listed or recognized components and either classified or furnished with complete installation instructions to the sign manufacturer.
- Electric signs, channel letters signs and section letter signs all require that all dead metal parts be connected continuously to the building equipment grounding conductor, without exception.
- Led power supplies are required to be installed in an additional electrical enclosure unless they are listed as an enclosure.
- All primary wiring to permanently connected electric signs is required to be enclosed. (In an enclosure not a sign body)
- Secondary wire must be suitable for the application, adequately supported, and protected from physical damage.

- Field installed electric signs and section letter signs require installation instructions and marking.

Special Thanks for Information and reprints:

National Fire Protection Association

Underwriters Laboratories, Inc Lee Hewitt, P.E. (PDE-UL 879 and 48 electric signs)

International Association of Electrical Inspectors Michael J. Johnston (I.A.E.I Education and Codes) www.iaei.org

National Sign Co.; Connecticut Sign Corp. LLC

USSC FOUNDATION www.usscfoundation.org

Gelcore (GE Tetra) www.gelcore.com ; Sloan Led www.sloanled.com;

Actown Electrocoil Inc www.actown.com

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