

Cracking the Code: NEC Article 100 and “listed” equipment

BY GUY HOLT

This article is the second in a series examining the effect of the National Electrical Code, NFPA 70, on motion picture production. In the previous installment we examined the purpose of the Code and the role played by the Authority Having Jurisdiction (AHJ.) In this installment we will examine the Article 100 definition of “Listed” to see what it reveals about the inter-relationship between codes, standards, and enforcement.

THERE ARE A NUMBER of terms used in the NEC whose meaning is key to understanding the Code. For that reason, it devotes Article 100 to defining these terms. One important term that appears throughout the Code is “listed.”

The NEC Article 100 definition of “listed” is:

“Equipment, materials, or services included in a list published by an organization that is acceptable to the authority having jurisdiction and concerned with evaluation of products or services, that maintains periodic inspection of production of listed equipment or materials or periodic evaluation of services, and whose listing states that either the equipment, material, or service meets appropriate designated standards or has been tested and found suitable for a specified purpose.”

To understand how the Code ensures the safe use of electricity, one must first understand the role “listed” plays. The North American electrical safety system consists of three interdependent parts:

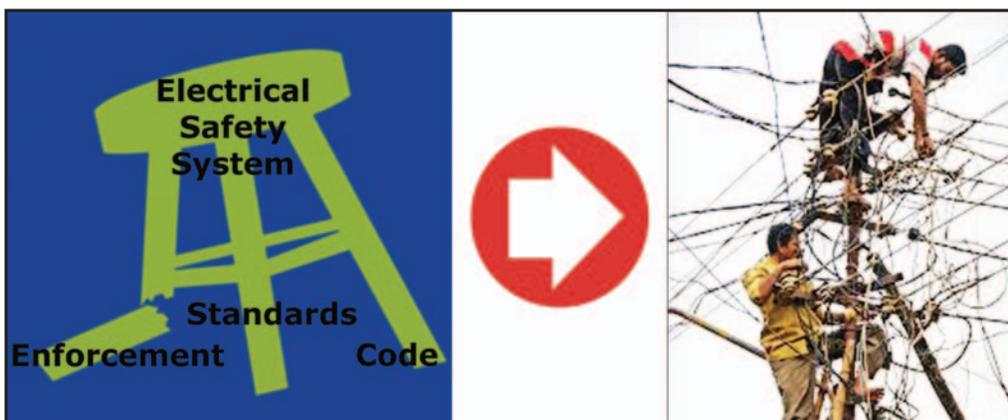


Figure 1 – A breakdown in enforcement can lead to hazardous situations like the right picture above.

codes, standards, and enforcement. Together they can be thought of as a three-legged stool. Each leg must be present for the system to support safety. No leg stands alone without its tie to the others. If one leg is missing, the whole system can break down, resulting in hazardous situations like that pictured in **Figure 1**.

The Code serves as the driver for safety by directing the safe installation of products, and by mandating the use of safe products. Listed products meet standards, are rated for their application, meet minimum safety requirements, and so fit within an integrated system. For example, when a 20 A circuit is installed in accordance with the Code, all the devices, from the overcurrent protection, to the wire, to the receptacle, are compatible. They are rated for 20 A, and are lab tested. This is just one example of thousands of requirements under which the Code and product standards are linked. Standards

development organizations (SDO), such as the Underwriters Laboratories (UL), provide the standards used in the Code (see NEC Informative Annex A for a list of product safety standards cited in the NEC).

The third leg of the safety stool is enforcement. Throughout the country there are electrical inspectors who act as the enforcement arm of a municipal, county, or state government. The inspector verifies that the installation complies with the Code as adopted in the inspector’s jurisdiction. This is a check on the safety system by an independent party, trained in the Code, who doesn’t have a vested interest in the design, construction, or operation of the site. The use of equipment certified and listed to appropriate standards ensures an Authority Having Jurisdiction (AHJ)’s approval.

According to Section 90.7, when products are labeled as having met the appropriate standard, additional evaluation by

inspection authorities at the installation site is normally not necessary, except to detect alterations or damage.

“For specific items of equipment and materials referred to in this Code, examinations for safety made under standard conditions will provide a basis for approval where the record is made generally available through promulgation by organizations properly equipped and qualified for experimental testing, inspections of the run of goods at factories, and service-value determination through field inspections. This avoids the necessity for repetition of examinations by different examiners, frequently with inadequate facilities for such work, and the confusion that would result from conflicting reports as to the suitability of devices and materials examined for a given purpose.” (NEC Section 90.7.)

Certification to a standard provides AHJs with reasonable assurances that the product or equipment is safe. A product listing or certification is not an approval (only the AHJ can grant that), but it goes a long way in facilitating the AHJ’s approval process. Since inspectors are generally not equipped to inspect for conformity to product standards, they rely on equipment certifications by testing laboratories as a basis for their approval of equipment. Which makes standards testing laboratories another key component of the electrical safety system.

This conformance assessment process requires entities to ensure that equipment is evaluated and tested to meet the applicable minimum product safety standards written by standards development organizations, or SDOs. In Section 90.7, the *Code* refers to these entities as “qualified electrical testing laboratories.” To meet this requirement, the Federal Occupational Safety and Health Administration (OSHA) created the Nationally Recognized Testing Laboratories (NRTL) program to identify and authorize qualified testing labs to list and label such equipment and to promulgate them through their product listing directories.

Underwriters Laboratories (UL)



There are approximately 20 certified listing agencies and, while they all draw on the same library of standards when testing products, Underwriters Laboratory is the best known. When a product obtains UL Listing or Listing by another NRTL, it is published in a list of ones that meet recognized standards—which is what “listed” means.

Once the product has been listed, the manufacturer is allowed to put a label on it with the logo of the listing agency, such as the UL mark, and specify the use for which it was manufactured, which makes it

the Institute of Electrical and Electronics Engineers (IEEE) and the National Electrical Manufacturers Association (NEMA).

Underwriters Laboratories (UL) is unique in that it is both a NRTL and the principal SDO for electrical standards that are *NEC*-related. Other NRTLs can list products, but they generally do so to UL standards.

The linkage between installation codes, product standards, and enforcement depicted in **Figure 2** also determines equipment design and adoption. The portable high-amperage disconnect switches we use on set are a good example of how enforcement is a driver for product design and adoption.

For many years, motion picture rental houses built their own high-amperage disconnect switches out of the same parts

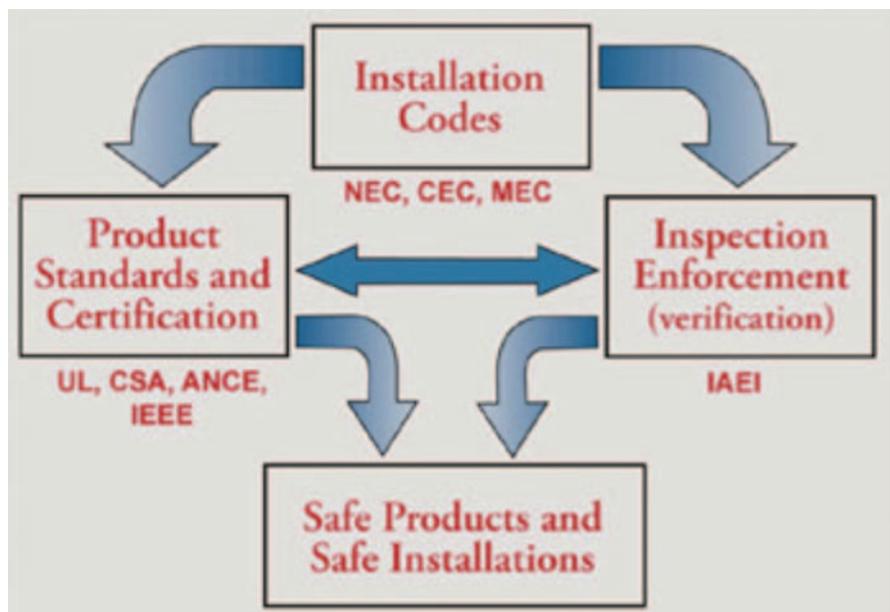


Figure 2 – The linkage between installation codes, product standards, and enforcement

“listed and labeled.” Because of the sterling reputation of nationally recognized listing laboratories, any appliance or device that is listed and labeled usually will be quickly approved by an AHJ if it is being used in the manner specified in the listing.

The relevant safety standards to which NRTLs test are developed by a number of standard writing organizations, such as

used in permanent installations. That is, a shop hand would wire a listed knife-blade style safety switch to cam-connector pigtailed. While this method remains an option to this day, it presents several safety issues (illustrated in **Figure 3**). For example, free-hanging tails leave potentially live connections exposed. To change a fuse requires opening the door. With the door

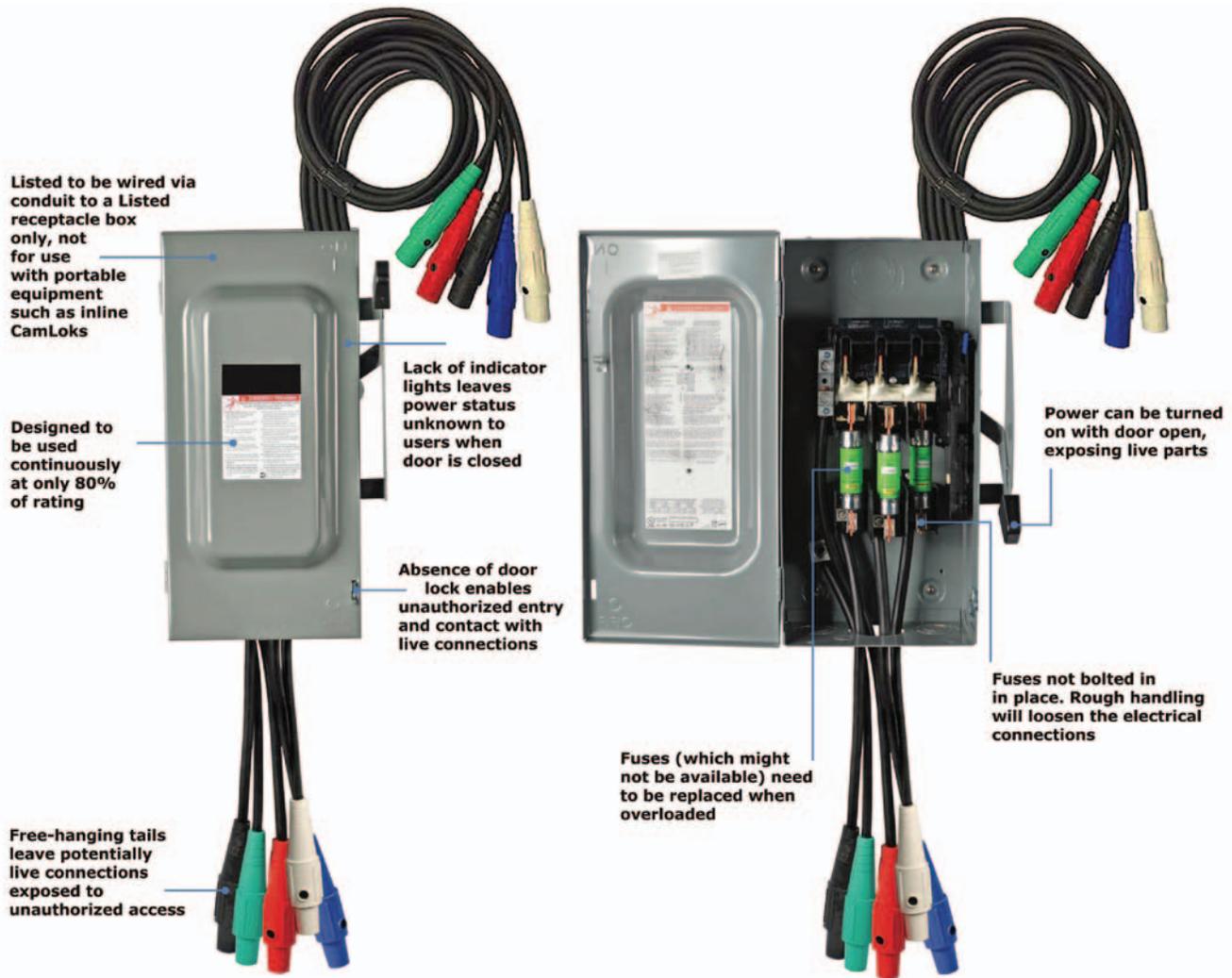


Figure 3 – Safety issues presented by combining tails with knife-blade type safety switches

open, the line side of the fuse blocks are still live, exposing the user to a potential shock hazard.

If exposure to live parts weren't reason enough, an AHJ could reject this combination of equipment for its noncompliance with *NEC* 110.3(B), since installation instructions must be followed as part of the listing of the electrical equipment. Section 110.3(B) states, "listed or labeled equipment shall be installed and used in accordance with any instructions included in the listing or labeling." The UL standard to which the knife blade safety switch is designed, tested, and listed (*UL* 334) is for permanent installations in which the switch is wired via conduit to a

receptacle box. It is that combination of equipment that has been tested in a UL lab to withstand a short circuit of at least 65,000 A, not the mash-up of portable and permanent distribution equipment depicted in **Figure 3**. This use of listed equipment for a purpose other than for which it is designed and tested could be challenged by an AHJ, and result in the shutdown of production until it is replaced with listed equipment (like that pictured in **Figure 4**) that meets the AHJ's approval.

Since certification to a standard driven by the *Code* ensures an AHJ's approval, manufacturers such as AC Power, LEX Products, and Indu-Electric design and build portable disconnects to the *UL1640*

standard in the hope they will be adopted by the end user (you and me) over a non-compliant alternative. For instance, since *NEC* Section 530.15, Enclosing and Guarding Live Parts, states: "Live parts shall be enclosed or guarded to prevent accidental contact by persons and objects." *UL* 1640: Portable Power-Distribution Equipment states: The enclosure of portable power distribution boxes: "shall be constructed so as to reduce the risk of unintentional contact with enclosed electrical devices, and to provide internal devices with protection from specified external conditions." (*UL1640* – 7.1.2)

And, switch and circuit breakers: "shall be operable from the outside of an enclosure and shall not be located behind a door unless



Figure 4 – Some of the UL1640 criteria to which manufacturers conform

live parts or wiring are not exposed during operation.” (UL1640 – 7.8.1)

To ensure an AHJ’s approval, manufacturers design their disconnects to these criteria. To prevent an individual from making unintentional contact with live parts, they put the switch grade breaker on the outside of the enclosure and spring-loaded cover plates over the female output receptacles.

And, since the *Code* requires equipment, located where significant fault current is available, have a high AIC Rating, manufacturers design and test their assembly of breaker and enclosure to withstand a short circuit of at least 65,000 A and continue to function. Shop assembled knife-blade safety switches undergo no such tests. AIC ratings are just one of thousands of requirements under which the *Code* and product standards are linked and reinforce each other.

By meeting the safety criteria of a standard, manufacturers provide AHJs with reasonable assurances that their product is safe and compatible with other portable power distribution equipment. Equipment used under conditions not consistent with

its listing will surely draw the scrutiny of an AHJ. That’s the last thing a production wants.

Next Installment

During a studio production in New York City, a luminaire arced and sputtered molten copper globules into the dry greens around it for several minutes until a fire broke out. Had the ground of the stage distro not been compromised by high impedance, the upstream breaker would have tripped almost instantaneously, thereby eliminating the possibility of a fire starting; or worse, a technician receiving an electrical shock. This episode highlights the importance of *NEC* Section 110.10: Circuit Impedance, Short-Circuit Current Ratings, and Other Characteristics.

Given the wear-and-tear on portable power distribution equipment (it gets set-up, broken-down, tossed on and off of trucks thousands of times) the coordination of circuit characteristics and components should be confirmed on each set-up. In the next installment of this series we look at three components of electrical circuits

(circuit breakers, ground impedance, and short-circuit current ratings) and how to coordinate them to assure electrical safety on set. ■



Guy Holt has served as a gaffer, set electrician, and generator operator on numerous features and television productions. He is recognized for his writing on the use of portable generators in motion picture production (available soon in book form from the APT Press). Guy has developed curriculums on power quality and electrical hazard protection that he has taught through the IATSE Local 481 Electrical Department’s “TECs” Program. He is the owner of ScreenLight & Grip, a motion picture lighting and sales company that specializes in innovative approaches to set power using Honda portable generators.