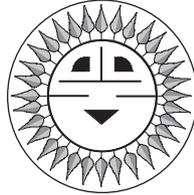


# Listing PV Equipment



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All manufacturers of PV equipment, both large and small, should consider having that equipment listed to standards established by Underwriters Laboratories (UL). The benefits of marketing listed equipment are numerous and were pointed out in the Code Corner Column in Home Power Magazine Issue 55. This column will present some of the finer points of the relationship between the National Electrical Code and listed equipment, and how the testing and listing laboratories do business.

## NEC Requires Listed Equipment

The National Electrical Code (NEC) establishes a set of safety requirements for electrical power systems that are installed in residential, commercial, and industrial locations. The NEC does not cover mobile installations (except RVs and house boats), nor does it cover installations owned and operated by utility companies on their own property used exclusively for the generation, transmission, and distribution of electrical power.

The NEC is published and updated every three years by the National Fire Protection Association. The most recent edition is the 1996 NEC. It is a safety and fire code that is nearly 100 years old and is the most comprehensive electrical code in the world.

The National Electrical Code is a model electrical code that has been legislated into law in at least forty states and most major municipalities throughout the United States. Local codes may be mandated that supplement the NEC and each jurisdiction may be using a version of the NEC that is not the most recent version.

The NEC requires that all equipment that is installed under the code be examined for safety. The authority

having jurisdiction (AHJ), usually an electrical inspector, is the person that makes this examination. To relieve the AHJ from having the extensive knowledge, test equipment, and experience to test and evaluate each and every component and piece of electrical equipment, a process of listing and labeling is used.

Listing and labeling is a process where an independent testing laboratory (recognized by the AHJ) tests and evaluates, in a rigorous manner, equipment and components against a set of detailed safety standards published by UL. The UL Standards are written to harmonize with the requirements of the NEC so that listed equipment will be reasonably safe and protect the user and associated property.

The listing and labeling of equipment provides the examination for safety required by the NEC and exempts the AHJ from inspecting each piece of equipment. The AHJ can then elect to accept the listing and labeling information as an indication that the particular equipment, when installed following the labeling and any instructions that accompany the product, will meet the overall safety requirements of the NEC.

Nearly every component in a conventional electrical system is listed and/or labeled. Listed items include: outlet cover plates, receptacles, switches, cables, wires, lamp holders, transformers, switchgear, disconnects, load centers, overcurrent devices, etc.

In residential, commercial, and industrial installations, the NEC deals with the electrical power system from the utility meter socket or point of service interconnection to the receptacle outlet or lamp holder. It also covers other types of electrical installations such as radio frequency systems, computer data installations, photovoltaic power systems, and a number of other electrical systems that may or may not be connected to a utility-provided source of electrical power.

## End Use Appliances

End-use appliances such as vacuum cleaners, computers, table lamps and the like are not covered by the NEC. However, most of these devices that are sold in the U.S. are tested to appropriate UL Standards and are so marked. This ensures that the device can be used safely when connected to an electrical system that meets the NEC.

## The Electrical System

When an electrical system is composed of listed components, installed in accordance with the requirements of the NEC, and inspected by the AHJ, there is a high probability that the system will be safe to use, operate, and maintain.

If the electrical system consists of a combination of listed and unlisted components and equipment, the AHJ has several options: examine the unlisted equipment for safety; require that the unlisted equipment be replaced with listed equipment where available; require that the unlisted equipment or even the entire system be examined by a qualified authority such as a testing laboratory or a Professional Engineer; or, refuse to accept the system.

Normally, complete electrical power systems are not listed. Complete systems are composed of listed equipment and components that are installed in accordance with the requirements of the NEC by a licensed electrician or electrical contractor and then inspected by the AHJ. Almost any system that requires separate and distinct components connected together with field-installed wiring falls into this category. For example, the electrical system in a building is installed in this manner.

A billboard lighting system is installed the same way. Listed lamp holders are connected with listed cable to a listed transformer, and are controlled and protected by listed switchgear and overcurrent devices. The wiring is field installed and inspected by the AHJ. Installations such as this are, by far, the most common. There has never been any intent in the NEC or local codes to list the entire system. To do so would require that all of the infinite number of possible combinations of components be tested separately and in combinations. In such a system, field-installed wiring would not be possible unless listed wiring harnesses with plug-in connectors were used. The costs in terms of time, testing laboratory capabilities, and funding make such a task nearly impossible, if not ludicrous.

Underwriters Laboratories will certify certain organizations to assemble subsystems like panel boards from UL-Listed components. These devices might include listed circuit breakers, listed relays or contactors, listed cables, listed connectors and similar items. The end item is not a system, but is certainly more complex than a single piece of listed equipment.

### Small Listed Devices

There are categories of small, self-contained electrical power systems that are listed because they are more like end-use appliances than electrical power systems. An example might be the small emergency lighting system required in commercial buildings. Such a lighting system consists of two lamps, a battery, a charger, and a control system. The system is factory assembled, tested as a unit at the factory, tested by the testing lab during the listing process, and then just mounted on the wall and plugged in. There is no field-installed wiring and no requirement for inspection by the

AHJ, although the local building inspector might inspect it for proper operation and placement.

Another example is the self-contained uninterruptible power supply (UPS) used for desk-top computers. As before, it is factory wired, listed, and plugged in. No AHJ inspection is required. Larger UPS systems can require field wiring with rooms of batteries and controllers that would require installation meeting NEC requirements and inspection by an AHJ.

A third example might be the solar-power path light which has a battery, a photovoltaic power source, and a light. It is factory assembled, listed by the manufacturer (if desired and sometimes required by local law), and inserted in the ground.

Photovoltaic (PV) electrical power systems are covered in the NEC in Article 690. Where Article 690 is in conflict with any other article in the NEC, Article 690 prevails because of some of the unique safety aspects of PV systems and the organization of the NEC. Most PV systems are installed using separate components and field-installed wiring and fall under the NEC.

The solar-powered path light, solar-powered calculators, and wrist watches are examples of items that would not fall under the NEC. However, in general, most PV systems, because they have an infinite number of possible component combinations, like all other electrical power systems, do fall under the NEC.

Any PV system, whether listed as an entire system, or installed in accordance with the NEC and inspected, should comply with the basic safety requirements of NEC Article 690 and the applicable UL Standards. These dual requirements are necessary because of the unique electrical characteristics associated with PV modules as power sources and with batteries as energy storage devices.

It is entirely possible to design a PV-powered system (such as a single-pole lighting system) complete from PV module to load, have the entire system factory assembled, and shipped to the field where it is turned on without any requirement for field wiring or assembly. Such a system could be listed as a unit by a qualified testing laboratory to UL Standards. For larger, complex systems, this is generally not done for the following reasons.

Listing means that the product, as evaluated by the testing house, meets the applicable requirements of the published standards at the time it is manufactured. Follow-up inspections and production line tests are required to maintain the authorization to apply the listing marks of the testing organization to the product. All product variations must be covered in the inspection

documents and changes cleared with the testing organization.

This process would be somewhat expensive for complex systems and, because of the vast number of possible combinations of electrical components and equipment, most electrical power system installers choose to use listed components, install them to the requirements of the NEC, and then have that installation inspected by the AHJ.

There is no history that establishes that a totally listed electrical power system is any safer than a similar system using listed components installed to meet the requirements of the NEC and then inspected by an AHJ. In fact, there are few, if any, examples of similar systems that are done both ways. Factory assembly of a system can usually be done under more carefully controlled conditions than a field assembly. On the other hand, a final inspection by the AHJ of a field-installed unit verifies that the system and components have not been damaged in shipping. The AHJ may also verify that the system being inspected has been installed properly and operates safely.

The UL Standards and the NEC are developed in close harmony by a group of professionals that include persons from the electrical equipment industries, government agencies, electrical inspectors, universities, and end users. The UL Standards are designed to be used with the NEC and visa versa. Electrical safety is the goal and it is being achieved in the United States on a daily basis.

### How to Work With a Listing Laboratory

An applicant for a product listing writes a letter to one of the testing laboratories (see access). The letter should contain as much detail as possible about the product and the intended uses of the product. Full diagrams, mechanical details, lists of materials, schematics, manuals, alternate materials that may be used, photographs, and identification of listed and recognized components are minimum requirements.

The testing laboratory evaluates the materials submitted and prepares a plan for testing and a cost estimate. These are returned to the applicant along with an agreement for Follow-Up Service. The testing lab also determines the number of samples that will be required for the evaluation.

If the applicant desires to have the product listed, a preliminary deposit is sent to the testing lab along with the signed Follow-Up Service Agreement and the number of product samples required for the test.

In some cases, the testing lab may observe or validate testing that the manufacturer does, but in many cases

the testing lab performs or contracts all of the required testing. A determination is made as to whether or not the product meets the required standards, and a letter is sent to the applicant stating any deficiencies.

The applicant makes the necessary corrections and resubmits the product.

When the tests show that the product is acceptable, the testing laboratory issues a final test report and a notice of product listing. The Follow-Up Services field representative visits the factory to verify that the products being manufactured are identical to those tested.

After the product is listed, follow-up testing begins and is paid for by the applicant. The Follow-Up Service is a method where the testing laboratory visits the manufacturing plant every three months and tests the listed product coming off the assembly line. This periodic testing and evaluation assures that the product has not been changed in any detail and that it still meets the initial standards to which it was tested.

At this point, the applicant is authorized to use the mark of the testing laboratory (e.g. UL or ETL) on the product and in advertising, and may continue to do so as long as the product continues to meet the requirements established by the listing.

### Summary

The increasing use of listed electrical equipment in the PV industry is a given. There are major benefits from manufacturing listed equipment. The NEC requires that all equipment be listed, and inspectors are enforcing this requirement. Procedures for obtaining a listing are well established. The cost may be less than anticipated for well designed products.

### Access

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