Code Corner The 1996 National Electrical Code and Cable Updates

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The final changes to the 1996 National Electrical Code (NEC) have been written, discussed, revised, and balloted. The 1996 NEC is nearing publication and should be available later this year. Adoption of the 1996 NEC by the many state and local governments is automatic, but may take much longer in other jurisdictions. There are some significant changes for 1996 that will effect the installation of PV systems.

Some additional information on the use of cables has come to light and should be of interest to PV installers doing commercial installations.

1996 NEC

Cable Marking

Section 200-6 (a) Exception No. 5 will now allow the grounded, small (18-4 AWG) conductors used in PV array wiring to be marked at the ends with white tape or paint. Until now, marking of conductors smaller than Number 6 AWG was not allowed, and the PV installer had a problem, because most of the sunlight resistant, single-conductor cable is black. Cable that has the necessary white color and outdoor rating is almost nonexistent.

Grounding

Section 250-93 has been revised so that the requirements for the DC grounding electrode conductor are similar to the requirements for the ac grounding electrode conductor. In most cases, where only the grounding electrode conductors are attached to the ground rod, the DC grounding electrode conductor can be as small as Number 8 AWG copper. The DC grounding electrode conductor is no longer required to be as large as the largest DC conductor in the system. There are still restrictions, so the new code should be reviewed when planning an installation. Yea! No more monster cables to the ground rod!

Definitions

Many of the definitions in Section 690-2 have been cleaned up. In particular, the terms “Power Conditioning Unit” (PCU) or “Power Conversion System” (PCS) have been replaced with the more commonly used term “Inverter”. Several other definitions (such as “Inverter Input Circuit”) were added to assist in the use of new sections of the code.

Diagrams

Although the grid-tied diagram in Figure 690-1 is still in the 1996 Code, the NEC Handbook for 1996 should have several example diagrams of other types of PV systems.

System Voltage

System voltage is now defined in Section 690-7 as the highest open-circuit voltage between any two conductors in the system. In non-residential applications, there is no longer a 600-volt limit on PV system voltages. However, there are stringent Code requirements in Article 710 for the installation of any electrical power system over 600 volts. Furthermore, the hardware required to install systems over 600 volts is expensive and difficult to find. Most PV modules are listed for operation up to 600 volts.

Circuit Sizing and Current

Section 690-8 (b) (3) and (4) now define the requirements for determining the input and output currents for the inverters. These calculated currents are to be multiplied by 125% before sizing cables and overcurrent devices to ensure that this hardware is not operated continuously at more than 80% of rating.

Flexible Cables

Section 690-31 (c) has been added to explicitly allow the use of flexible, portable cords for moving parts of a tracking PV array. This will allow the SO, SOE, and SOJ cables to be used when they are listed for outdoor use with the “W-A” marking. Ampacity tables are referenced (Section 400-5), and a temperature compensation table is given (Table 690-31).

Small-Conductor Cables

If it looks like USE-2, feels like USE-2, and the manufacturer certifies that it is just like USE-2, then Section 690-13(d) now allows small 18-16 AWG cables that are listed for outdoor use to be used for module interconnections. These cables cannot be marked

USE-2 because of the small size. Underwriters Laboratories (UL) will be working with the cable manufacturers to list such cables and mark them with a designation that indicates they can be used in PV systems. These smaller cables will have application to the high-voltage grid-connected systems where the string currents are low.

Grounding
Section E (690-41-47) was extensively revised and, while not as clear as it could be, makes a lot more sense. It really says that all PV systems need equipment grounds and that all ground rods (ac and DC) should be tied together.

Marking
Section 690-52 requires that the installer mark the PV system with the system ratings at an accessible location at the PV disconnect.

Current-Limiting Overcurrent Devices
Section 690-71(c) specifically requires that a current-limiting overcurrent device be used on battery circuits.

Battery Cables
Section 690-74 allows the use of flexible cables that are listed in Article 400 for connections between a fixed wiring system terminated near the battery and the battery. They are also allowed between the battery cells. This was done to prevent damage to the batteries from too stiff cables, and to eliminate the use of non-listed welding and "battery" cables.

CABLE UPDATE
In past issues of Code Corner in Home Power, the use of conduit has been presented for containing module wiring. Typically, the diagrams show the use of THHN insulated conductors in conduit between modules and from the array to the disconnect inside the building. The use of THHN in conduit that is exposed to weather or other wet conditions is not allowed by the NEC since THHN cables are not listed for wet locations —only for dry and damp locations. Such dry and damp locations would be inside buildings and in protected areas like crawl spaces.

Section 100 of the NEC gives the definition of dry, damp, and wet locations. All locations exposed to the weather are considered wet. The NEC Handbook explains that if a conduit is mounted in a wet location, then the conductors installed in that conduit must also be rated for wet locations. Apparently, the conduit provides only mechanical protection and not moisture protection. This has been verified in the field when PV junction boxes installed with conduit have been found full of water when opened. Also, most underground conduits are considered to be filled with water unless specific measures are taken to prevent moisture and moist air from entering. The moisture in humid air condenses when it comes into contact with the cooler sides of the buried conduit.

Cable types that have a 90°C insulation when wet are XHHW-2 (similar to USE-2) and RHW-2. Other cables types such as THHW, THWN, and RHW have a 75°C insulation when wet. Since most modules require the use of 90°C conductors and most module junction boxes operate at temperatures approaching 70°C (the upper temperature limit for 75°C cables), it would appear prudent to use the 90°C XHHW-2 or RHW-2 type conductors when wiring modules with conduit.

In the next Code Corner, the overall list of items that should be considered with respect to balance-of-system design for safety and durability will be discussed.

The author is willing to answer questions on PV design and code issues relating to this and previous Code Corner Columns. Phone, Fax, or write to him at the address below.

Access
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