PV Odds & Ends

by John Wiles

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My presentations on PV and the *National Electrical Code (NEC)* take me all over the United States. This regular input from PV professionals serves as an ongoing source of information related to the equipment, hardware, and installation techniques being used by PV system designers and installers across the country to streamline the installation of safe and effective systems. A few recent items of interest follow.

PV on Metal Roofs

Section 250.110 of the *NEC* requires any exposed, non-current-carrying, conductive surface that may become energized be grounded to minimize electrical shock hazards. These surfaces include the PV module frames, metallic module mounting racks and, in the case of some roof-mounted systems, metal roofing material.

Some PV systems may operate at close to 600 volts and can pose a significant shock hazard if they are allowed to energize conductive exposed surfaces that may be touched. Effectively bonding these conductive surfaces together and grounding them will minimize shock hazards.

PV arrays installed on metal roofs should be grounded in a manner that limits potential shock hazards.

There are two primary wiring methods for connecting PV modules together—using exposed single-conductor cables, and using conduits. Each dictates a different grounding method, but in either case, PV modules must always be grounded properly. (For more information, see "PV Array Grounding" in *HP102*.)

Exposed, single-conductor cables that connect PV modules together can come into contact with the module mounting racks. Movement of the cables from wind, rain, and ice could compromise the conductor insulation and potentially energize the racks and metal roofing. Where exposed single conductor cables are used, the racks and the roof should be grounded. One technique is to install an appropriate grounding terminal/lug on each seam of a standing-seam roof, and connect an appropriate grounding conductor to those terminals and the equipment-grounding system. Since many standing-seam roofs are coated with a durable paint, it is usually necessary to make a connection to each panel of the roof and to make sure each of those connections penetrate the paint of the roofing panels.

When conduit is used between the individual modules and there are no exposed, single-conductor cables, then it is unlikely that either the module racks or the roof would require additional grounding. The module frames should always be grounded and the conduit that surrounds the conductors effectively protects them from damage. The conduit may be of an insulating type, like rigid nonmetallic conduit (RNC), or a metal type, like electrical metallic tubing (EMT). The EMT requires grounding; the RNC would not be grounded, but both would provide the desired physical protection. If the conductor insulation should fail, the conduit would prevent the rack or the roof from becoming energized. In this case, neither the metal racks nor the metal roof require grounding, except in the event that significant PV module damage could be expected. Such damage could cause the internal connections of a shattered PV module to contact the rack or the roof.

New Grounding Methods & Materials

Although listed PV modules are marked for grounding at specific points, hardware instructions do not generally address grounding the module at the mounting holes or at other locations besides the specified marks. Section 110.3(B) of the *NEC* requires that the instructions and labels provided with a listed product be followed.

New PV module grounding devices designed to minimize installation time and material costs are entering the market from Wiley Electronics, UniRac, and others (see Access). Unfortunately, even though a few PV manufacturers may furnish tech bulletins that detail the use of alternative module grounding points, all available techniques may not have been reviewed by Underwriters Laboratory (UL). The UniRac and Wiley products are not listed for use with any specific PV module, and there is no clear indication of compatibility with a particular module or mention of these grounding devices in most of the current PV module instruction manuals. As a result, it's up to the local electrical inspector, or "authority having jurisdiction" (AHJ), to approve or reject the use of these new products.

UniRac Grounding Clip.

I have been making formal and informal inputs to UL for several years concerning module grounding and asking UL to encourage module manufacturers to "tighten up" their grounding instructions and procedures. I have also been directly encouraging module manufacturers to have their modules tested and listed by UL with these new grounding products, and to provide that listing information in the instruction manuals, so the inspectors won't have any questions about determining the code compliance of this technique.

Securing Exposed Conductors

Most PV modules are manufactured with generously long (40 to 48 inches) output pigtail leads with connectors on the ends. The excess lead length must be securely fastened to the module frame or array mounting rack to prevent abrasion and damage by exposure to the elements.

Above: Black UV-resistant cable ties used to secure array wiring. At right: Stainless steel "loop clamp" and hardware.

Most installers use black plastic wire ties (cable or "zip" ties) as an easy and quick method to secure the extra length. This fastening method meets *NEC* requirements for good workmanship and protects the conductors from damage. Although black plastic cable ties marked "UV resistant" are suitable, in the hot and sunny Southwest, some fail after only a few years. (White cable ties are not resistant to ultraviolet radiation and should not be used.)

For our installations here at New Mexico State University and elsewhere, we have started using a rubber-cushioned, stainless steel loop clamp attached to the array rack with stainless-steel hardware (1/4-inch bolt, nut, and lock-washer). The loop clamp's EDPM rubber coating protects the conductor insulation from the clamp's sharp edges. (See Access for recommended brands and suppliers.)

Other Questions or Comments?

If you have questions about the *NEC* or the implementation of PV systems that follow the requirements of the *NEC*, feel free to call, fax, e-mail, or write me at the location below. See the SWTDI Web site (below) for more detailed articles on these subjects. The U.S. Department of Energy sponsors my activities in this area as a support function to the PV industry under Contract DE-FC 36-05-G015149.

Access

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The 2005 *National Electrical Code* and the *NEC Handbook* are available from the National Fire Protection Association (NFPA) • 800-344-3555 or 508-895-8300 • www.nfpa.org

Photovoltaic Power Systems & the 2005 National Electrical Code: Suggested Practices • www.nmsu.edu/~tdi/Photovoltaics/Codes-Stds/PVnecSugPract.html • Manual, 144 pages

Hardware Suppliers:
McMaster Carr • 562-692-5911 • www.mcmaster.com • Loop clamps (part numbers between 3325T22 and 3225T35)

UniRac • 505-242-6411 • www.unirac.com • Module grounding clips

Wiley Electronics • 845-247-2875 • www.we-llc.com • Module grounding products