Drake Chamberlin and Bob-O Schultze

Solar electric systems and the National Electrical Code ® are interfacing at an ever increasing level. Several years ago, inspectors showed little interest in these systems. As photovoltaic technology has evolved, efforts have been made to better define the Code as it applies to solar and other renewable energy installations. Unfortunately, the failure by the Code forming committee to include the PV Wrenches experience and perspective will cause some parts of the new 1999 NEC to contain unrealistic and unworkable provisions on day one of publication.

Safety

Basic safety devices quickly became mandated for off grid systems. All wires coming from a battery bank were required to have over current protection. Fuses and breakers needed to have DC ratings.

As the solar code continues to evolve, more detailed questions are being asked. New requirements have been implemented, and more are being proposed.

The Issue

Unfortunately, certain requirements increase the cost of solar electric systems and/or decrease efficiency. Many are questioning the necessity of some of these provisions.

It is the intent here to examine these requirements, to see what is necessary and what is not. Code language is often difficult to understand and is open to interpretations. I will attempt to clarify some of these code interpretations from a Wrench point of view.

Liquidtight Flexible Conduits

One possible requirement that has been discussed lately concerns the use of liquidtight flexible conduits. Mr John Wiles, in Code Corner, is concerned that the 60°C wet rating of liquidtight flexible nonmetallic conduit might not be adequate for modules. Although it is a favorite wiring method of many installers, John recommended that it not be used.

The wet rating of both metal and nonmetallic liquidtight flexible conduit is the same, 60°C. It is readily observable that liquidtight flexible metal conduit is often used for the connection of commercial compressors, which are often located in direct sun. If these conduits are forbidden on the basis of temperature, the standards for low voltage solar electric systems would become more stringent than those required for ac wiring of up to 600 volts.

The Wire to Use

Another question regards the temperature rating of the wiring used in module junction boxes. Mr Wiles writes that a 90°C wiring requirement may soon be extended to all listed modules.

In Code Corner of HP issue #62, he wrote that I [Drake] "thought there wasn't much reason to use 90°C conductors on PV modules."

But my view is that the 90°C, dual rated wire, THHN - THWN-2, is the best choice for solar module connections.

Although all the data is not in, it seems possible,at least in some locations, that wiring could get hot enough to need 90°C insulation. This wire is the most accessible conduit wire on the market, at least in this area. It is easy to install, inexpensive, and happily, rated at 90°C. It covers all the bases; equipment compatibility, code compliance and economic viability. It is unquestionably adequate for safety.

Temperature Rating of Wire and Breakers

A related issue raised concerns the compatibility of circuit breakers and wiring of different temperature ratings. To clarify the issue, it is standard procedure to connect a wire rated at 90°C centigrade to a 75°C

breaker. The actual operating temperature of the wire is the issue.

For example, THHN wire is rated at 90°C. However, wire sizes AWG #14, #12 and #10 (the most popular wire sizes used for PV module connections) are only allowed to be operated at 15,20, and 30 amps respectively. (A note at the bottom of Table 310-16 requires these limits).

Many popular circuit breakers are rated at 75°C. (John had sent me an e-mail, correcting my mistake, when I wrote that Square D breakers had a higher rating). Common GE, ITE and Square D breakers are rated at 75°C. Whenever a number 14, 12 or 10 THHN wire is connected to one of these breakers, it is a connection between a 90°C rated wire and a 75°C rated breaker. As THHN is widely used, this is a very common wiring situation.

It is permissible to run larger wires, operated at 75°C, to 75°C breakers, but one would want to have a specific reason for doing so. In any system, If the run is long, the voltage drop would be too great. For wires bigger than # 10, it is safest to size wiring for the 60°C rating corresponding to Table 310-16 at a minimum.

Shaping the Evolving Technology

PV is an evolving technology. Field data needs to be evaluated to demonstrate what is needed and what is not. I would like to hear from anyone who has seen safety problems with solar electric systems. Have battery cables failed? Have inverters gone out of control and had to be shut down from the DC side? Have modules been destroyed by ground faults or reverse polarity hookups to batteries? Has anyone been shocked or injured by a low voltage solar array? Are flexible conduits disintegrating in the sun?

There are many issues that need to be addressed. The tendency has been to make complex, a type of system that can be installed very simply. Solar installers are happy to do what ever is necessary to make their installations safe. The question is, “are all these complexities really necessary, or do some represent arbitrary rules?”

To produce efficient and cost effective systems, it is important to avoid becoming encumbered by needless institutional barriers. We want to be certain that money spent makes for better systems.

Batteries and Battery Cables

I get more mail about using non-UL listed battery cables than about any other issue. It is Mr Wiles’ belief and expressed opinion that using ANY unlisted wire in a PV battery system is “unacceptable”. Pretty strong language. Let’s take a look at the realities.

For starters, batteries, the heart of all off-grid PV systems, are not UL listed. There is no requirement in the Code for listing, labeling or identifying batteries. Nothing is said in NEC 480 (Storage Batteries) about listing for either the batteries themselves OR about battery interconnection. Section 690-74 for PV systems, on the other hand, says that flexible battery cables “shall be listed for hard service use and identified as acid and moisture resistant.” Neither section speaks to solid, bus bar type of interconnection. Mandating listed flexible cables alone seems pretty random and arbitrary to me.

The reality is that there are untold MILLIONS of flexible battery cables in use every day in cars and trucks. These cables are subjected to all manner of vibration, flexing, high heat, freezing cold, water, mud, etc. Welding cables are designed to spend their whole working life carrying huge current loads at similar DC voltages AND survive being dragged across the floor time after time AND withstand incredible heat from sparks and hot slag every day. Most are rated by the manufacturers to 105°C, but not listed. Battery cables in most PV systems are subjected to NONE of these things. Is this a real problem?

True, there are big variations in the quality of battery cables designed for automotive use. I’ve seen some of such poor quality that I wouldn’t use them for any purpose. At the same time, I’ve seen some imported UL listed 120 vac receptacles that I wouldn’t use in a doghouse. Assuming the use of a good quality cable of the proper AWG size, the question is one of cost rather than safety. Listed flexible cable in sizes 2/0 and larger is THREE TIMES the cost of an equivalent battery or welding cable. They are not readily stocked by battery shops. While most RE installers and suppliers will do a good job making up custom cables from listed wire if requested, the probability of a poorer terminal connection is much higher than from a national cable manufacturer, where powerful hydraulic crimping equipment is employed.

The big problem, as I see it, is the Code’s failure to recognize that the vast majority of PV systems operate at less than 50 VDC and to develop a lesser standard for these systems. Let’s face it, safety issues caused by voltage leaking through wire insulation in a 24 VDC system is just not the problem it is at 240 vac or higher. There seems to be no safety vs cost benefit to hold low voltage systems to the 600 V wire standard. One of the main reasons the NFPA tries hard to involve manufacturers in the Code forming process is to get a good feel for this cost vs safety issue.

Unfortunately, our industry is still so small that we tend to fall through the cracks and get saddled with

unnecessary—and expensive—regulations. The academics, quasi-governmental laboratories, and the standard electrical associations just can't have the perspective or experience we Wrenches do. Mr Wiles and Company's failure to tap our knowledge in their efforts to update the Code was, and is, a huge and unsupportable mistake.

The real danger lies in the reality that some people will distrust or reject the whole Code because of a very few obviously flawed, ill-conceived, and onerous sections. Many systems are never inspected at all. Even in those that are, the inspector can't be expected to catch every violation. Safety is the issue. If the Code requires unnecessary or unreasonable expenses due to the inexperience or conflicting agenda of the section forming committee, installers will not follow it and THAT will cause hazards to exist.

Calling All Wrenches

A "Wrench" is someone that is actually involved in the installation of RE systems. In other words, them what's doin' as opposed to them what's talkin'. IPP members, folks that have installed their own systems to Code, and many others are mostly Wrenches. If the shoe fits... tell us about it!

Access

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