PV LABELING

NEC 2017 SECTION 690 SOLAR PHOTOVOLTAIC SYSTEMS

HellermannTyton

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This white paper summarizes some of the current and new requirements regarding proper labeling for standard solar installations.

The new NEC 2017 has been published and released, giving the industry a glimpse into many new changes and additions in Article 690. As PV systems grow and evolve, the required labeling needed to change with it to ensure safe and informative installations also grow. Like any evolving process, input from many sources was required to gain a better understanding of what works and what does not, so the process of change could proceed in a way that makes sense for everyday use in real world applications.

Code making panel 4 of the NEC 2017 reviewed hundreds of public inputs. Each suggestion was weighed, reviewed and compared to other similar requests and then voted up or down based on all relevant data and substantiations. Many suggestions were for improved labeling. In the end, the panel addressed a number of inputs; some of the changes are outlined in this article.

Please note that just because the new NEC 2017 is in effect, each State and or local jurisdiction may not automatically adopt the new code. Many are on specific code review cycles and may continue to enforce earlier revision of the code. Check with your local authorities to be certain which code revision is currently in force before labeling.

Figure 1

New Bipolar PV System Requirements

Making changes that are relevant to existing and future systems is important. Part of the effort has involved addressing labeling efficiency and eliminating or reducing labels that no longer serve a valid purpose. For instance, certain labels are no longer considered necessary, such as the bipolar label listed under 690.7(E)(3) from the NEC 2014 code. Disconnection of the neutral cannot result in overvoltage of the array, since the ground-fault detection system is required to separate the array into two distinct arrays during fault conditions; therefore, condition 3 is unnecessary. *(Figure 1)*

Figure 2

So, to make this more relevant, the NEC 2017 Code Article 690.31(I) will now indicate that a new label shall be used to clearly mark bipolar photovoltaic systems with a warning notice indicating that disconnecting the grounded conductor(s) (not the neutral) could result in overvoltage of the equipment. *(Figure 2)*

This change is linked to the revisions related to solidly grounded and reference grounded systems. The warning about the disconnection of the grounded conductor in a bipolar system is only relevant for solidly grounded bipolar systems, which are extremely rare. The revision in 690.31(I), for the NEC 2017, clarifies (for reference grounded bipolar systems) that these bipolar arrays must be separated into two distinct monopolar arrays when the grounded conductor is interrupted, so overvoltage does not occur.

Figure 3

Simplifying Labeling for Power Information

Another example is in NEC 2014 Article 690.35(F). Originally, this marking requirement was seen as necessary for electricians, based on the thinking that ungrounded conductors were somehow safe. *(Figure 3)*

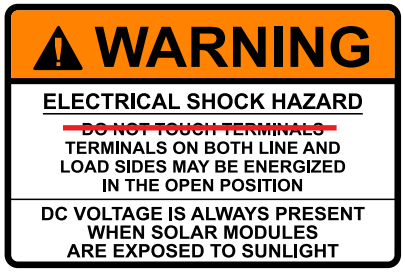

Figure 4

That has never been true, so the requirement for this marking will be eliminated, reducing the number of labels required on a PV system and simplifying the labeling process even more.

Speaking of simplifying labeling, the following labels are still required, but the words "DO NOT TOUCH TERMINALS" have been removed. This is found in 690.17(E) of the NEC 2014 code, but will be found in 690.13(B) in the new NEC 2017 revision. *(Figure 4)*

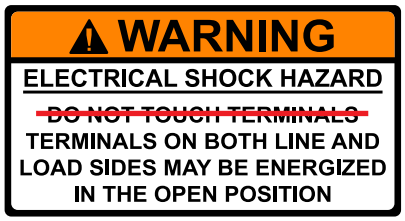

Figure 5

As of the first draft revision of NEC 2017, 690.53 has changed to simplify the required power information. When editing current code, the panel typically documents the changes as shown in the bullets you see below. This helps by preserving the current code text, while also showing what was eliminated or changed. *(Figure 5)*

690.53 DIRECT CURRENT PHOTOVOLTAIC POWER SOURCE

- ~~(1) Rated maximum power-point current.~~
- ~~(2) Rated maximum power-point voltage.~~
- (3) Maximum ~~system~~ voltage.
- Informational Note to (3): See 690.7(A) for maximum PV system voltage.
- (4) Maximum circuit current. ~~Where the PV power source has multiple~~

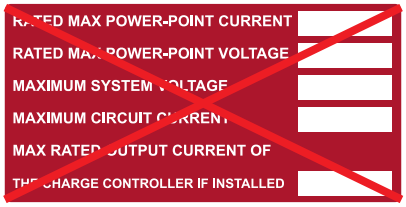

Figure 6 *Old label*

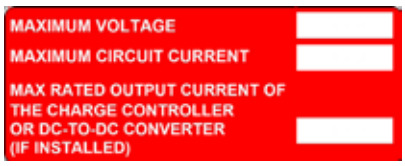

Figure 7 *New label*

Figure 8

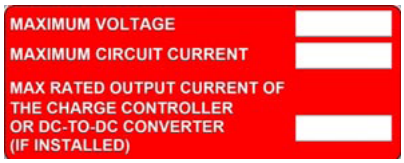

Figure 9

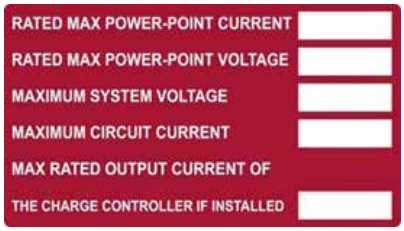

Figure 10

~~outputs, items (1) and (4) shall be specified for each output.~~

- Informational Note ~~to (4)~~: See 690.8(A) for calculation of maximum circuit current.
- (5) Maximum rated output current of the charge controller or dc-to-dc converter (if installed). *(Figure 6)*

In the example to the left, power requirements were simplified for the installer. *(Figure 7)*

The following label already exists in Article 690.55 of the NEC 2014, but the language was clarified slightly so that the new NEC 2017 code now reads: "Energy storage systems shall be marked with the maximum operating voltage, including any equalization voltage. If solidly grounded, grounded circuit conductor shall be marked to indicate the polarity." The previous code revision simply indicated: "Photovoltaic power systems employing energy storage shall also be marked with the maximum operating voltage, including any equalization voltage and the polarity of the grounded circuit conductor." *(Figure 8)*

In the NEC 2014, this section of code required the polarity of the grounded conductor to be marked in all cases *(Figure 9)*. In the 2017 code, only solidly grounded systems need the polarity to be marked as part of this provision *(Figure 10)*. Many systems do not have grounded conductors, so the provision in NEC 2014 did not make sense. Also, other marking requirements in 690.31(B) require general markings that include polarity, making this polarity marking requirement redundant. NOTE: SOLIDLY GROUNDED MEANS THAT AC CONDUCTORS ARE USED 99% OF THE TIME.

Changes for Stand-Alone Systems

On a similar note, language was clarified in article 690.56(A) regarding stand-alone systems. References to the AHJ and related codes were removed.

690.56(A)

A) Facilities with Stand-Alone Systems. Any structure or building with a PV power system that is not connected to a utility service source and is a stand-alone system shall have a permanent plaque or directory installed on the exterior of the building or structure at a readily visible location ~~acceptable to the authority having jurisdiction~~. The plaque or directory shall indicate the location of system disconnecting means and that the structure contains a stand-alone electrical power system. ~~The marking shall be in~~

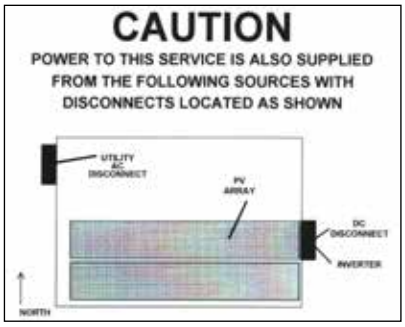

Figure 11

~~accordance with 690.31(E).~~

This revision removes subjective content that might be confusing for enforcement personnel. The AHJ, in this case, could be both the building department and the fire department. These different AHJs could have different opinions on location. Simply stating that the sign must be in a readily visible location is preferred. Fire departments are most likely your best choice to consult with on the best placement of the sign. The reference to the wiring methods section of 690 was not appropriate for this sign and was deleted in the code revision. *(Figure 11)*

Rapid Shutdown

Regarding the fire department and the fire marshal, one of the more important changes involves how a system is identified for rapid shutdown. The details around rapid shutdown are still being discussed but, regardless of the outcome, fire marshals want clear identification regarding rapid shutdown.

A public input was submitted to NFPA1, which is currently updating the IFC (International Fire Code) for 2018. This input is described below and also applies to the NEC 2017 revision so that there is consistency between both documents.

The new language listed in 690.56(C) will require a label that is similar in concept to the two examples below:

- The first label would be required for a PV system that shuts down the array and all conductors leaving the array, which will represent the NEC 2017 rapid shutdown requirements. *(Figure 12)*
- The second label would be for PV systems that only shut down the conductors leaving the array, which is representative of the current rapid shutdown requirements defined in the NEC 2014 revision. *(Figure 13)*

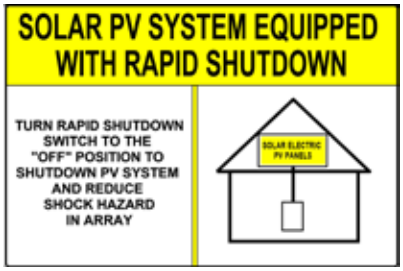

Figure 12

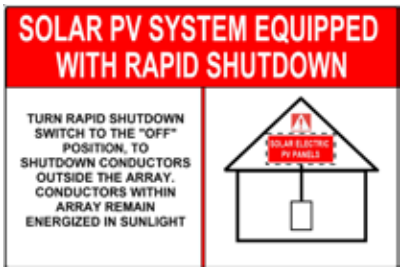

Figure 13

The label shall include a simple diagram of a building or roof. Diagram sections in red signify sections of the PV system that are not shut down when rapid shutdown switch is operated. Sections of the diagram in yellow signify sections of the PV system that are shut down when the rapid shutdown switch is operated. Buildings with both types of rapid shutdown, or a system or a PV system with one of the rapid shutdown types and a PV system with no rapid shutdown, shall have a detailed plan view, showing each different PV system and a dotted line around areas that remain energized after the rapid shutdown switch is operated.

Figure 14

Finally, the rapid shutdown switch shall have a label located on or no more than 1 meter (3.3 ft.) from the switch that will appear as shown. *(Figure 14)*

As you can see, there are many changes – both subtle and obvious – that were considered for the NEC 2017 revision.

The goal is to continue working toward better code language that helps installers, inspectors and designers meet the challenges of the future and ensure a safe installation environment.

In the new NEC 2014/2017 code, the code panel made a specific point of using the word "Label" to better define the method of marking. Some examples from the NEC 2014 code include:

NEC 110.21(B): "Where required in this code, any field applied LABELS, warning(s) and marking shall comply with ANSI Z535.4."

INFORMATIONAL NOTE: NEC 110.21(B)(5): "ANSI Z535.4 – 2011 Product Safety Signs and LABELS, provides guidelines for the design and durability of safety signs and labels for the application to electrical equipment."

All other warning and caution labels, unless otherwise specified, should meet the requirements of ANSI Z535.4 – 2011 per the informational note in Article 110.21(B) in the NEC 2014/2017. The ANSI standard requires that Danger, Warning, and Caution signs used the standard header colors, header text, and safety alert symbol on each label. The ANSI standard requires a heading that is at least 50% taller than the body text. While not required in the NEC 2014, the message text should be at least .12" tall. If we compare this to Occupational Safety and Health Administration (OHSA)1910.145 and the American National Standard Institute (ANSI) Z535, it is specified that signs must be visible at a safe viewing distance from the hazard. They also recommend the use of safety alert symbols, where applicable.

Figure 15

In the NEC 2011 code, the label would be and is currently acceptable *(Figure 15)*.

Figure 16

In the NEC 2014/2017 code, the format of this same label would look as follows *(Figure 16)*.

The text is the same. The only difference is that the second label is designed based on the requirements of ANSI Z535.4.

The orange header color serves to satisfy the new code requirements when approving installations. On the one hand, this appears to make the work of labeling more complex. However, it also allows the market to now provide a variety of labeling packages that are pre-made for use by the installers, cutting time and costs out of the process.

Many inspectors and installers believe the use of an etched plate is required in order to pass inspection and that the marker must last for 20 years.

In the new NEC 2014/2017 code, the language was modified to include the word LABEL within the code.

NEC 110.21: "The LABEL shall be suitable for the environment where it is installed."

This means that the label should be designed to withstand the outdoor elements, but does not specify a time period. So, what does that mean for customers, designers, or municipalities that seem fixed on having a 20-year rating for labels used on field marked equipment? First, there is no drawback to using an engraved plate, but the installer needs to be aware that most phenolics are not ultraviolet (UV) rated for outdoor use. Engraved plates can be costly and have limitations when it comes to meeting the requirements of the most recent standards (which now includes reflectivity). The new standards are written to allow the installer to pick from a variety of identification methods. For instance, the IFC 2012 says that the materials used for marking shall be reflective, weather resistant, and suitable for the environment.

Adhesive label manufacturers, in the label converting industry, will typically certify their label materials up to five years for outdoor durability in direct exposure to the elements. Many fully pre-printed labels have a nine-year rating, which is exceptional in the labeling market. Other manufacturers, like HellermannTyton, have tested their labels using Xenon Arc technology to 20+ years with little or no degradation of the label. The key is to research the material specifications before selecting a label. The typical definition of "outdoor durability" is that the labels should show little or no degradation during a defined time period and then slowly degrade as the years go by. Labels in shade or protected from direct exposure to sun and the elements can last two or three times longer before starting to break down.

As mentioned, certain labels do not have to conform to the ANSI standards and that some labels need to have reflective characteristics. The NEC and IFC actually go one step further in distinguishing critical labels needed to prevent a life-threatening hazard. It has become imperative that labels provide emergency responders with appropriate warning and guidance with respect to isolating the solar electric system. This includes identifying energized electrical lines that connect the solar modules to the inverter, as these should not be cut when venting smoke from a burning building. Cutting into a live conduit could result in a 520 volt jolt, so safety is a primary concern.

The International Fire Code and National Electrical Code specifies that Electrical Metallic Tubing (EMT) conduit and raceways must be marked no less than every 10 feet, at every turn, above and below penetrations, and on all exposed raceways, cable trays, and other wiring methods. The labels also must be visible on the covers or enclosures of pull boxes and junction boxes as well as conduit bodies in which any of the available conduit openings are unused.

The new NEC 2014/2017 code finally bridges the gap between the NEC 2011 and the IFC 2012 in which the NEC 2011 indicated that the required text should read as "PHOTOVOLTAIC POWER SOURCE" while the IFC stated that the text should read as "WARNING: PHOTOVOLTAIC POWER SOURCE" and be reflective with 3/8" white characters on a red background. The NEC 2014/2017 panel modified the code to support the IFC requirements so that both codes now agree on wording and format.

So per the new NEC 2014/2017, the label is to be printed with the following text: WARNING: PHOTOVOLTAIC POWER SOURCE. Further, the NEC and IFC require that these labels must have reflective properties so that they are clearly visible in the beam of a flashlight. The IFC is specifying that the markings must be detectable from a distance, which denotes that the minimum text height is 3/8" using white lettering on a red background. *(Figure 17)*

Figure 17

Also, printed labels must now spell out the word PHOTOVOLTAIC. The term PV is no longer acceptable on a printed label. In previous code revisions, the following label would have been acceptable. *(Figure 18)*

Figure 18

In the new NEC 2014/2017 code, that same label must be printed as follows: *(Figure 19)*

Figure 19

The IFC would prefer to see labels that identify the main service disconnect or critical disconnects with reflective, red and white labels.

Finally, the California Department of Forestry and Fire Protection (CAL FIRE) code recommends that the markers meet UL969, an adhesive label specification, which is another added consideration for the installer when determining how best to label a system. If we examine the new requirements and compare and contrast those to the various environmental factors such as surface type, UV exposure and color, the installer has many things to consider in selecting a labeling solution. These include:

1. Is the marker reflective? Is reflectivity required?
2. Does the marker meet UL969 requirements?
3. Can the marker easily adhere to conduit?
4. Is the marker UV resistant?
5. Will the marker stick to a variety of surfaces for the life of the product?
6. Is the printed verbiage correct?
7. Are the printed characters at least 3/8" tall, where required?
8. Are the colors correct?

Figure 20

Also, in NEC690.31(G)(1), the installer must clearly mark circuits that are hidden under build up, laminate, or other membrane roofing materials that are not covered by PV modules. This typically can be a metal shingle label or something permanent that can be attached to both tar and composite shingles. *(Figure 20)*

NEC 2014/2017 and IFC 2012 offer new insights into the dynamics of labeling the PV installation. The updated standards open the door for the acceptable use of high-quality labeling products that are designed to meet the critical UV exposures. These suitable labels also offer a permanent marking on low-energy surfaces, such as powder coat paints found on many of the new breaker boxes and inverters. These updates come at an opportune time when the market is now capable of supplying label inks and adhesives that are UV stable and have the ability to adhere to various surfaces without losing adhesion due to temperature or environmental changes.

These new and improved label materials also provide a cost advantage to the installer. For example, if a high-quality, UV stabilized, pre-printed or semi pre-printed label is used, the cost of labeling a typical installation goes from $60 to $70 per installation down to approximately $10 or $20 per installation. Not to mention, the installer is more likely to be truly compliant to the requirements of the NEC and IFC as well as applicable UL, OSHA and ANSI standards.

LOCAL REGULATIONS

The one caveat that installers must consider are the local regulations. Some communities mandate the use of an engraved plate, and in those instances the installer must comply. Yet, in most districts, there is no specific definition of what type of marker is required. This gives the installer more variability in selecting a labeling solution.

Again, there is no right or wrong answer on marker selection as long as the installer is meeting the requirements of the AHJ in all instances. The trend that we are seeing is that labeling products with specialized features, such as reflectivity, are the vanguard of the new era.

The market is evolving and like any other industry during growth, the players will seek to find the best solutions at the lowest cost. The cost of not passing an inspection is just as important as the cost of a marker. As the standards become more defined, additional solutions will become available to the designer, engineer and contractor.

Many adjustments are sure to come as the industry progresses and labeling grows with the changes to become a standard that everyone can define and implement now and in the future.

Figure 21

Figure 22

Figure 23

Figure 24

Figure 25

NEC 690 LABEL APPLICATION EXAMPLES

NEC690.31(G)(3-4)

For use on EMT conduit, raceways, enclosures, and combiner boxes and disconnects. *(Figure 21)*

NEC690.31(G)(1)

For use on shingled roofs where circuits are embedded. *(Figure 22)*

NEC110.27(C) or OSHA 1910.145(f)(7)

Warning labels are used to represent a hazard. For use on the breaker panel, main disconnect, as well as junction and combiner boxes. *(Figure 23)*

NEC690.13(B) *(Figure 24 & 25)*

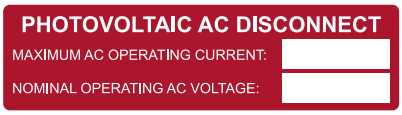

Figure 26

690.54 *(Figure 26)*

Figure 27

Figure 28

NEC690.13(B)

If equipment is energized from more than one source, the disconnecting means must be grouped and identified. In this case of the labels shown above, a printer can be used to print the breaker series or disconnect means in the white middle portion of each label. *(Figure 27 & 28)*

Figure 29

NEC690.15(C)

Non-load, break-rated disconnect mean shall be marked "Do Not Open Under Load." *(Figure 29)*

Figure 30

NEC690.33(E)(2)

Interruption current – a type that requires the use of a tool to open will be marked "Do Not Disconnect Under Load." *(Figure 30)*

Figure 31

NEC690.54

All interactive points of interconnection with other sources shall be marked at an accessible location at the disconnecting means as the power source with the rated AC output current and nominal AC operating voltage. *(Figure 31)*

Figure 32

NEC705.12(B)(3-4) and NEC690.59 *(Figure 32)*

Figure 33

NEC705.12(D)(3)(4) and 690.59 *(Figure 33)*

Equipment containing over current devices in circuits supplying power to a busbar or conductor supplied from multiple sources shall be marked to indicate the presence of all sources. Typically used on the breaker panel. Individual breakers should also be marked.

Figure 34

NEC690.31(B)(1-2)

PV system circuit conductors shall be identified at all accessible points of termination, connection and splices. Where conductors of more than one PV system occupy the same junction box, raceway or equipment, the conductors of each system shall be identified at all terminations and splice points. Cables can be marked using UL969 approved self-laminating vinyl labels. *(Figure 34)*

Always check local codes before defining labeling formats.

About HellermannTyton

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