



THE
CADMUS
GROUP, INC.

NYSERDA Solar PV Quality Assurance Program: Technical Results for Installers

Shawn Shaw and Matt Piantedosi
October 25th, 2012

Agenda

- Introduction
 - About Cadmus
 - Goals and Inspection Process
- Common Installation Issues
 - Shading/TSRF
 - PV Source Circuit
 - Balance of System
- Conclusions/Q&A

About Cadmus

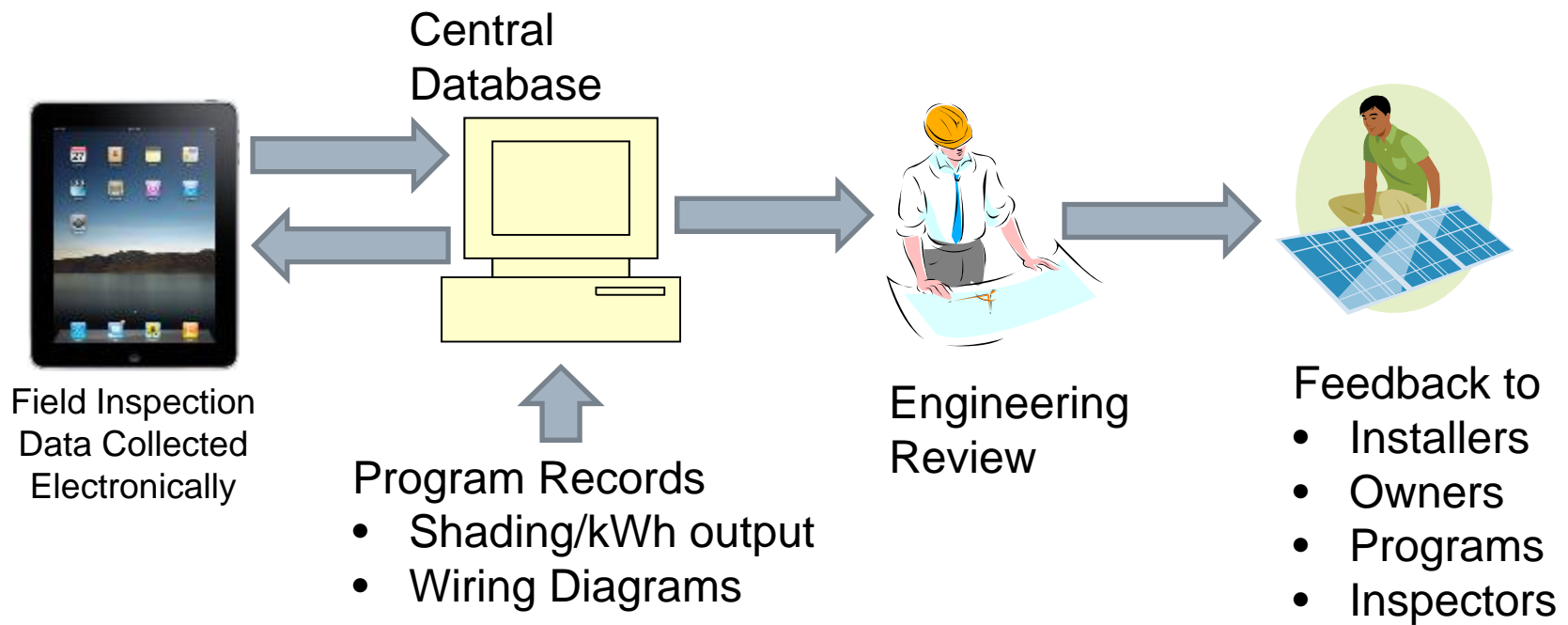
- Energy and environmental consulting firm
- Completed well over 1,000 solar inspections and design reviews
- Owner's Agent on ~50 municipal solar projects
- Staff includes
 - PE's
 - Licensed electricians
 - NABCEP certified installers



The Inspectors

- Shawn Shaw (PM)
- Bill Atkinson
- Matt Piantedosi
- Glenn Burt
- Ron Burden
- Robert Lamoureux
- John Calhoun
- Jason Hinsey
- Chris Warfel

Our Inspection System



Goals of the Inspection Process

- Ensure that public funds are supporting PV systems that are:
 - Safe
 - Productive
 - Long-lived
- Provide independent feedback to help installers improve installations and minimize customer call-backs
- Verify that installed system matches NYSERDA records

And to Avoid...



The Inspection Process

- NYSERDA marks project complete in Power Clerk
- Cadmus compiles completed projects every week and flags for inspections
 - 15% of projects by full installers
 - First 3, then 30% of projects by provisional installers
 - Probationary installers' sites inspected at 30% or NYSERDA's discretion

The Inspection Process Cont'd

- Scheduling
 - Grouped by inspector and by region
 - Email to installers
 - Phone calls to owners
 - Confirmation email to owners, cc installers and inspector
 - We make every effort to provide installers with at least 5 business days notice of confirmed inspections
 - All inspections scheduled at the convenience of the owner

The Inspection Process Cont'd

- Inspection completed
- Inspection report submitted to Cadmus PM for internal review
- Approved report sent to NYSERDA
- NYSERDA reviews and forwards to installer for corrections

The Inspection Process Cont'd

- NYSERDA determines what, if any, re-inspection action is needed
 - Desktop review
 - Full re-inspection
- Re-inspection is completed, if necessary
- Same QA/submission process as regular inspections

Key Policy: Ladders and Roof Access

- All inspectors bring at least a folding ladder to the site
- Customer/installer ladders may be used, at inspector discretion and risk, once onsite if necessary
- Cadmus carries full relevant insurance policies, which can be provided upon request within 24 hours

Key Policy: Communication with Owners

- We do NOT communicate inspection results to owners unless it is an immediate safety concern
 - However, we cannot stop a customer from watching us inspect and asking questions. The best way to keep a customer from seeing installation problems is to have none.
- Owners can request copies of inspection report from NYSERDA (inspections@nyserda.org)

Key Policy: Dangerous Systems

Presents an imminent hazard to people and/or property

1. Contact Cadmus PM
 1. PM will notify NYSERDA
2. Contact installer
3. Secure system to minimize risk
4. Inform system owner/building occupants of situation
5. Installer to communicate planned repairs to NYSERDA and apprise when completed

Inspecting for Shading/TSRF

- Inspectors use Solar Pathfinder and Solmetric SunEye tools
- Results are compared with PON 2112 application materials
- More emphasis on sites with heavier shading



Common Shading/TSRF Issues

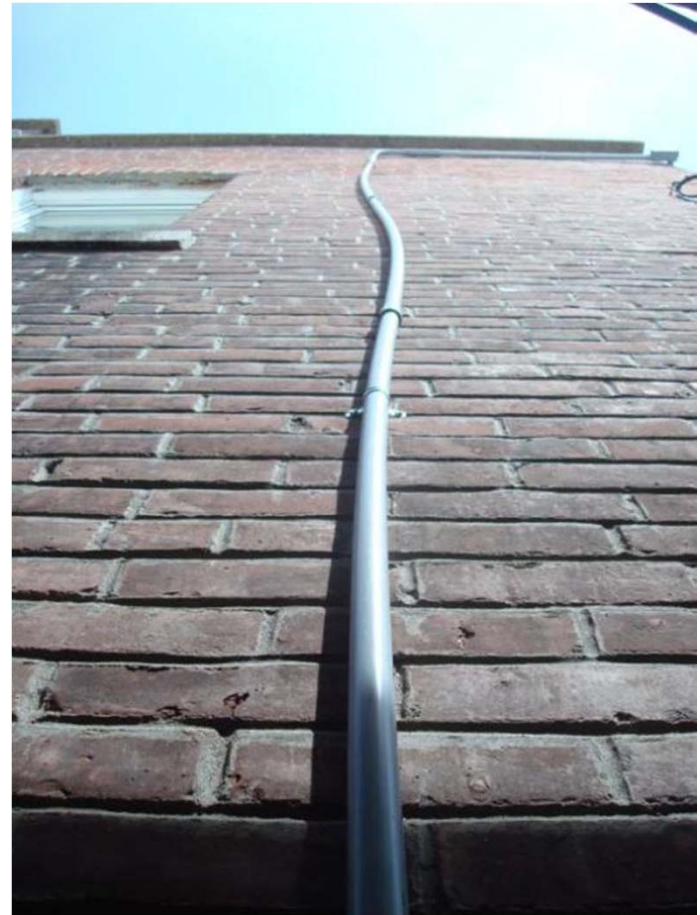
- Including planned tree removal
- Assuming credit for micro-inverter use
- Assuming credit for deciduous trees in fall/winter months
- Measurement location

Most Common Installation Issues: PV Source Circuit

- Missing/inadequate expansion fittings
- Protecting conductors from damage and contact by unqualified persons
- Grounding

Expansion Fitting Issues

- Missing expansion fittings can:
 - Damage fittings and entry points into enclosures, compromising weather resistance
 - Abrade/damage wires
 - Pull conduit loose from attachment points
 - Conduit bending/stress



Expansion Fittings (PVC)

- *“Expansion fittings for PVC conduit shall be provided to compensate for thermal expansion and contraction where the length change, in accordance with Table 352.44, is expected to be 6 mm (1/4 in.) or greater in a straight run between securely mounted items such as boxes, cabinets, elbows, or other conduit terminations.”*



Based on a conservative temperature difference of 60 deg F, PVC conduit runs over 10' between fixed points require expansion fittings. See calculation below:

$$1/4" = 0.25"$$

$$60 \text{ deg F temp change at } 2.43" / 100' \text{ (T352.44)}$$

$$2.43" / 100' = 0.0243" / 1'$$

$$0.25" / 0.0243" = 10.3'$$

Expansion Fittings (EMT/RMC)

- Reference 300.7, 352.44
- NEC does not define allowable expansion but based on same $\frac{1}{4}$ " as PVC
 - Multiply PVC expansion by 0.2
 - Typically affects runs of 50-100 ft

Protecting Conductors

- Minimize risk of short circuits, ground faults, and electric shock
- Reference NEC 690.31, 338.10, and 334.30



Examples of Conductors at Risk of Long Term Damage



Best Practices-Protecting Conductors (338.10, 334.30)

- Securely fasten conductors to racking, away from roof surface
- Use raceway when running conductors between arrays
- Avoid bringing bare wires over roof (or other) edges
- Imagine 20+ years of wind, rain, ice, and animals when installing



Protecting Conductors from Accidental Contact

- Ground mount systems
- Manufacturer supplied connectors do not address per NEC
- Conductors must be “not readily accessible”



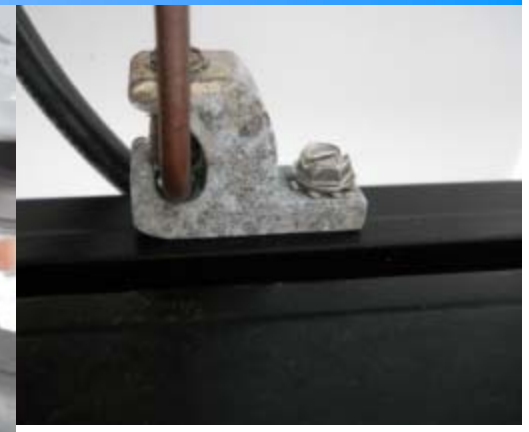
Protecting Conductors-Best Practices

- Fencing
- Mesh
- Non-conductive covering



PVSC Grounding Issues

- Compliance with product listing
- Connections



PVSC Grounding Best Practices

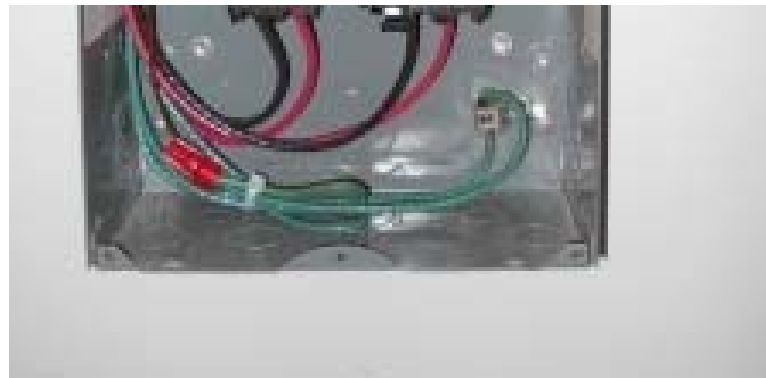
- Use lugs and other components rated for outdoor use
- Beware of dissimilar metals
- Ensure all teeth used to penetrate anodizing make good contact
- Bond rail sections together
- Make sure the mounting structure is bonded to ground with good mechanical connections

Common Installation Issues- Balance of System

- Grounding
- Labeling
- Bonding neutral to ground

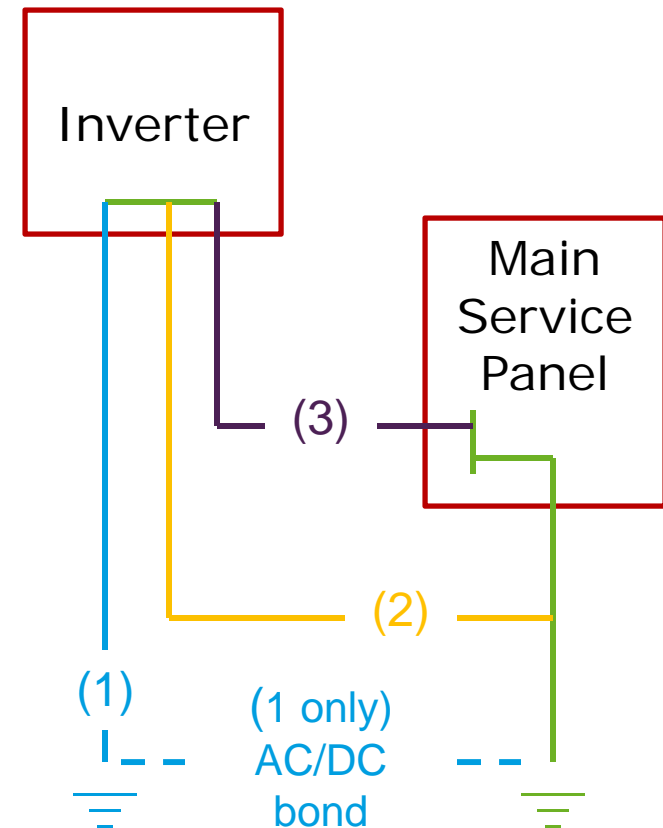
BOS Grounding Issues

- Reference 690.47, 250.64, 250.66, 250.166
- #1 Issue is **continuity** of the GEC



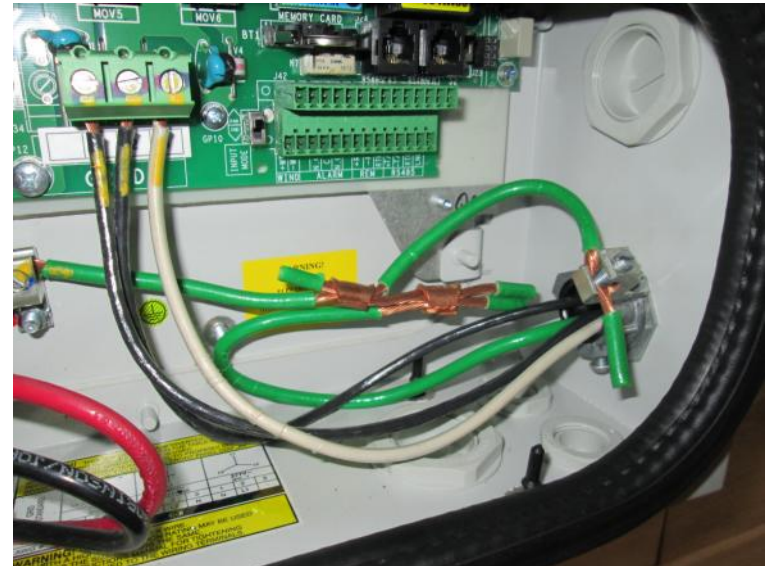
690.47(C) Systems With Alternating-Current and Direct Current Grounding Requirements

- **DC Grounding Electrode Conductor (GEC)** runs to an electrode or ground bar:
 1. A separate electrode installed for DC system grounding
 2. The electrode that serves for AC system grounding
 3. Main panel ground bar
 - May also serve as equipment grounding conductor



BOS Grounding Best Practices

- Ok to use combined GEC/EGC but has to meet requirements of both
- Minimum GEC #8AWG
- Only irreversible splices/crimps



Labeling

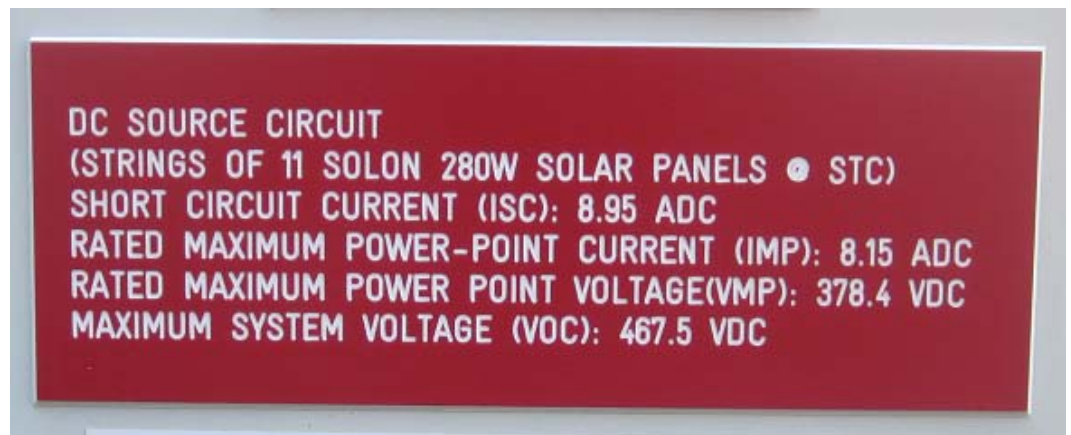
- Multiple labels required per NEC
 - 690.14 (disconnect label)
 - 690.17 (not always applicable)
 - 690.53 (DC system characteristics)
 - 690.54 (AC characteristics)
 - 690.64 (backfeed breaker)
 - 705.10 (power source directory)
- Labels should be legible and durable—especially outdoor labels

Labeling Issues



Labeling Best Practices

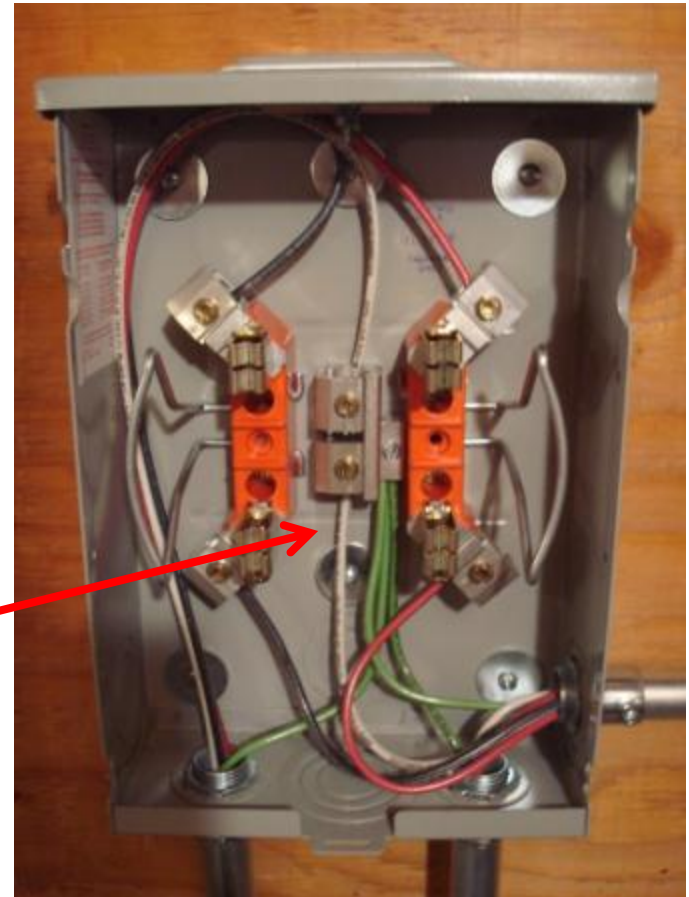
- Etched plaques durable for outdoor use
- Not covering manufacturer labels
- Complete and accurate



Bonding Neutral and Ground

“A grounded conductor shall not be connected to normally non-current carrying metal parts of equipment, to equipment grounding conductors(s) or be reconnected to ground on the load side of the service disconnecting means except as otherwise permitted in this article.”

Common issue – Neutral connected to PV production meter frame



Thank You-And Questions?

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Webinar Questions and Answers

The following questions, adjusted for context, grammar, and clarity, were asked during the Installer Technical Webinar on October 25, 2012.

Questions Related to Inspection Process and Introductory Slides

1. Is FSC Group related to Cadmus?
 - a. Yes-Freeman Sullivan Group (FSC) is a subcontractor that Cadmus uses for call center services. FSC is responsible for calling customers selected to receive an inspection, scheduling the inspection, and notifying customer, installer, and inspector via email to confirm the appointment.
2. How does Cadmus/NYSERDA determine whether a system requires a desktop or field re-inspection?
 - a. The re-inspection process begins with reviewing the installer-supplied photographs of modifications made to address Cadmus' report findings. From there, based on the type and quantity of issues found, the quality of the supplied photos/documentation, and the degree to which the issues have been addressed Cadmus may conduct a re-inspection. In general, systems with simpler issues and better photographs documenting changes made will be far less likely to require a field re-inspection than systems with numerous/complex installation issues and/or poor photographs of changes made.
3. I have not been receiving notification of upcoming inspections. Can you tell me why that is?
 - a. We make every effort to ensure that installers receive notice of upcoming inspections in a timely manner. All communication with installers related to scheduling inspections is done via email and Cadmus' schedulers use installer email addresses on file in the Power Clerk database. If an installer is not receiving notice of upcoming inspections via email, it is possible that their email address in Power Clerk is out of date or that Cadmus' scheduling emails are being caught by spam filters. If this continues to be a problem, please email shawn.shaw@cadmusgroup.com
4. What do we do when the local electrical inspector and Cadmus disagree on an installation issue?
 - a. It is important to note that Cadmus and the AHJ fulfill two different roles. The AHJ inspects a system to determine if it is legally compliant with relevant codes. Cadmus, on the other hand, is inspecting to determine compliance with NYSEDA program requirements. In these cases, NYSEDA will review the situation and make a decision on a case by case basis.
5. If cited for inappropriate use of a system component, such as a particular type of grounding lug, can an installer submit relevant documentation from the manufacturer of the component as evidence of correct use?
 - a. Yes. While Cadmus' inspectors make every possible attempt to correctly identify system components used, this is not always possible and demonstrated compliance with relevant manufacturer instructions or Nationally Recognized Testing Laboratory (NRTL) listings will be considered.

Questions Related to Shading and Total Solar Resource Fraction

1. We have been doing a lot of new construction projects. Is it possible that this is going to cause a discrepancy between our company's shading measurements and those found during the inspection?
 - a. It is possible that this will result in some differences. If, for example, you measure shading on a blank site before a house is built, you will likely get a more conservative estimate of available solar radiation (i.e., more shading) than what Cadmus will find during the inspection. On the other hand, new construction happening to the south of the array location could increase shading found during the inspection. Thus far, this has been a fairly rare occurrence and we will certainly work with the installer on a case by case basis if this issue should arise.
2. Does NYSERDA include any adjustments for snow cover when verifying shading/TSRF calculations?
 - a. No, not at this time.

Questions Related to Common Issues Observed in the PV Source Circuit (i.e. between solar array and inverters)

1. Does covering used to protect ground mount array conductors need to be non-conductive?
 - a. No, metallic coverings are acceptable so long as they are properly grounded per NEC 690.43.
2. Discuss why mounting systems connected to grounded array frames, as shown on Slide 26, do not meet NEC requirements for grounding of metallic components per NEC 690.43
 - a. NEC 690.43 requires that "exposed non-current –carrying metal parts of module frames, equipment, and conductor enclosures shall be grounded..." This includes the module frames and mounting racks. By reference, 690.43 includes 250.136, which allows supporting structures **in electrical contact** with metallic components grounded per 250.134 (also referenced in 690.43) to be considered grounded. Electrical contact between the support structure and the grounded module frames requires a mechanical fastening that penetrates anodizing, paint, or other coatings. Allowed connection methods that maintain a bond in grounding equipment are summarized in NEC 250.8. A U-bolt or similar compression-based means of attaching portions of the support system to the grounded portions of the racking is not generally listed to maintain the electrical continuity of the ground path.
3. Is PVC conduit ok to use as a means of protecting rooftop conductors from damage, given that it is generally rated for a temperature limit of 122°F?
 - a. According to NEC 352.12(D), PVC conduit is not to be used in applications where the temperature exceeds 122°F. To determine the relevant rooftop temperature, installers should consult relevant weather data, such as ASHRAE or the Solar ABC's website for the installation site. Once the ambient high temperature is determined, NEC 310.15(B)2C provides the relevant rooftop ambient temperature adder, which is added to the ambient high temperature. If that value exceeds 122°F, then PVC conduit is not appropriate for the application. In general, PVC conduit may be used in most parts of

New York State so long as it is supported more than 3 1/2 “, or more, above the roof surface.

Questions Related to Common Issues Observed in the Balance of System (inverters to point of interconnection)

1. How can a system have a combined Grounding Electrode Conductor (GEC) and Equipment Grounding Conductor (EGC)?
 - a. While Cadmus is not able to offer technical installation training as part of its contract with NYSERDA, the GEC and EGC are permitted to be combined into a single conductor, so long as that conductor meets all of the relevant requirements of the EGC and GEC. These requirements are included in 690.47, 690.46, 690.45, and 690.43. In cases of differing requirements (e.g., conductor size), the more stringent requirement must be followed.
2. Electrical inspectors sometimes require bonding of neutral and ground in the production meter for the PV system, citing it as a requirement for a separate utility service on the premises. How does this compare with reports where Cadmus cites violations of 250.24?
 - a. In many cases, the types of meters used to measure the electricity generation of solar PV systems are the same as those used, for example, as the service entrance meter for a residence. In cases where a solar PV system is interconnected on the **line side** of the main service disconnect, it is correct to bond neutral and ground in the meter enclosure. However, Cadmus frequently sees this issue in meters installed on the **load side** of the main service disconnect. The simplest way to distinguish between the two scenarios (or to explain it to an electrical inspector who questions the practice) is to note that a PV system installed on the load side is connected to the building electrical system via a backfeed-rated circuit breaker. As such, the production meter cannot be a new service and is subject to the requirements of NEC 250.24(A)5, which expressly indicates that AC grounded conductors may not be bonded to metal enclosures on the load side of the service disconnect.