



Inspector Training Workshops

Module One

Photovoltaic Labeling based on 2008 NEC

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HW Construction Department
Wayne, NJ
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Contents



- Site inspections with attention on Labeling
- Circuitry;
- Branch circuit and feeder identification
 - Service equipment identification
 - Inverter input and output circuits
 - PV output and source circuits
- MM Labeling Handout supplied
- Questions and feedback encouraged



NJCE Inspectors



- Protect integrity of Clean On-site Renewable Energy (CORE) program
- Good system practices
- Safety with Regard to Proper Application
- Labeling Properly Formatted and Designed





Integration of PV Systems

- Modules forming an array
- Inverters converting DC to AC
- Metering, internal and external
- Equipment and hardware
- Combiner boxes (fused or non fused)
 - Wiring
 - Disconnects, over current devices
 - Service equipment





Why Label PV systems?

- SAFETY
- NEC and OSHA Requirements
- Provides System Checks and Verifications for Personnel
- How many of your customers know the acronym PV?
 - The National EC uses the word Photovoltaic not an abbreviation.
- Alerting ALL Users to the Potential Dangers?
- DANGER KEEP OUT
- Illuminated Modules Can't be Turned Off!



Labeling



- Types and Design
- UV Rated?
- Size, Color and Shape?
- Codes and Standards
 - NEC 110, 230, 408, 690 and 705
- OSHA



Types and Styles



- Vinyl
- Paper
- Plastic
- Self Adhesive
- Phenolic
- Durable
- Ultra violate protected
- Metal, Non corrosive
- Other/Rated for Location



Rooftop Combiners Nicely Identified



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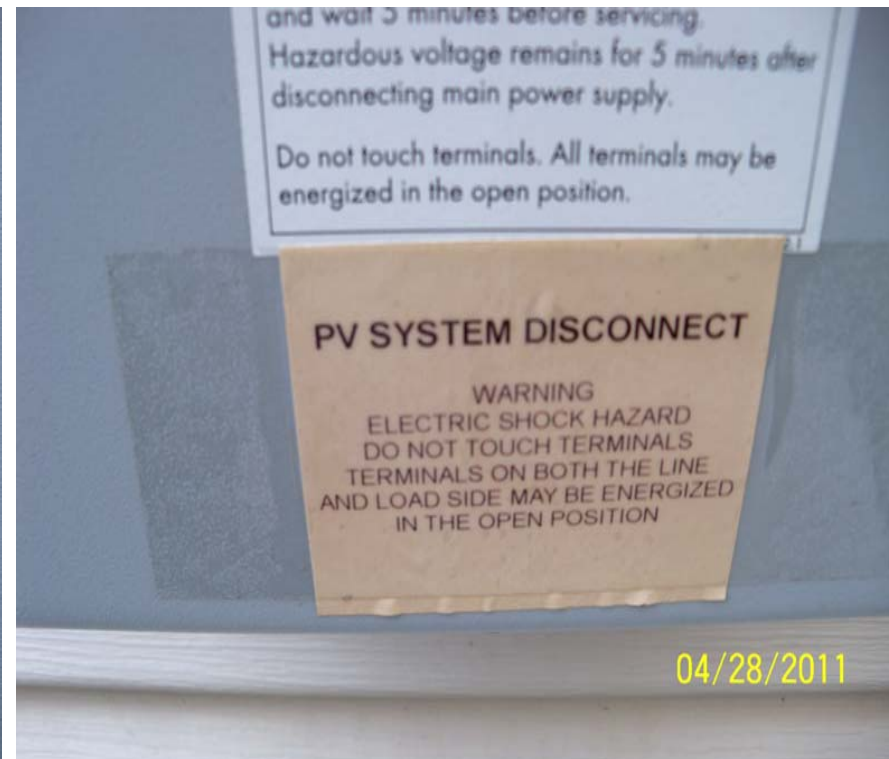
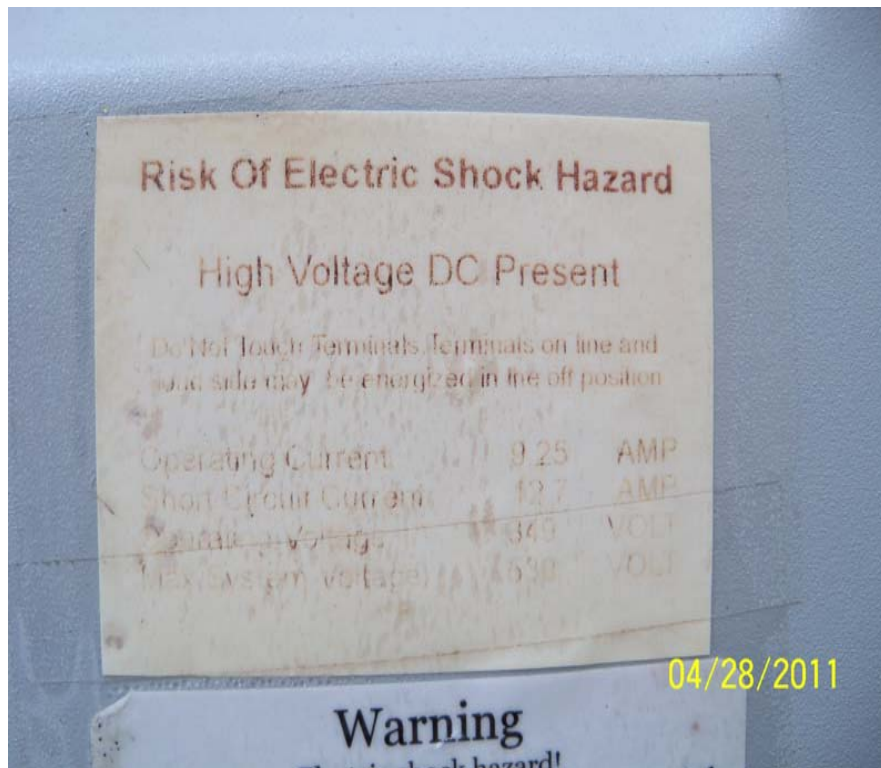
Frequent NJCE Failures

- Not applied, Missing
- Incorrect or missing data
- Not Permanent
- Labels won't stick to;
 - Crinkles finishes
 - Wet locations
 - Dirty surfaces



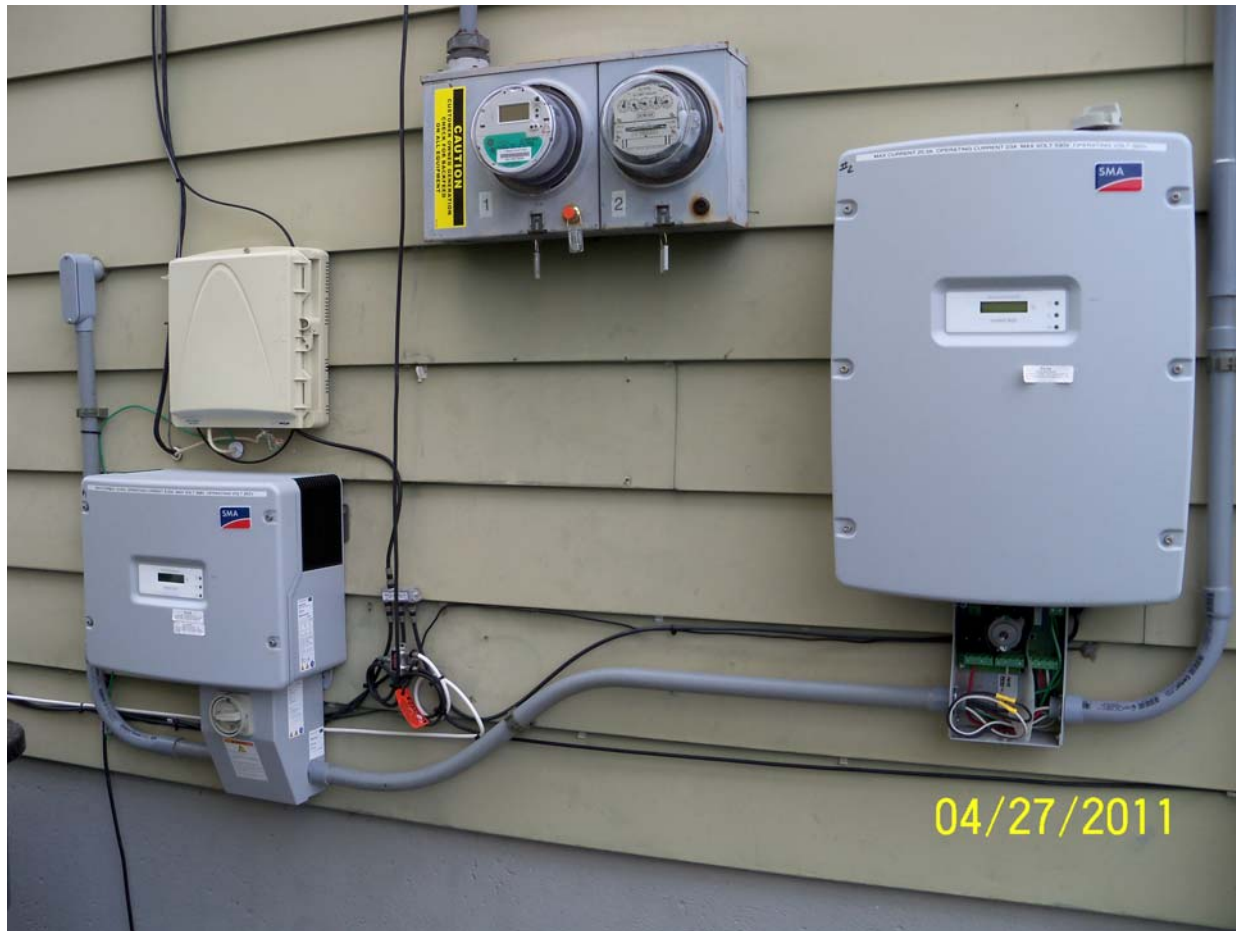


Are these Outdoor Rated?





Paper, poor choice





Paper doesn't last





Manufactures Nameplate Information





Equipment Nameplates



Inverter

Utility Interactive Three Phase Photovoltaic Inverter

Rated Output Power:	260000W	DC Max. Voltage:	600 VDC
AC OPERATION (V)		DC Operating Limits:	295-500 VDC
Nom. voltage:	480	DC Maximum Current:	1030 A
Min. voltage:	422	DC max short circuit current:	1600 A
Max. voltage:	528	Operating Temp Range:	-30 to 50C
AC OPERATION (A)		AC Voltage Accuracy	
Max. current:	316	Low: +/- 5% < 2 seconds	
Max. branch circuit:	400	High: +/- 5% < 1 second	
AC Operating Frequency:	60Hz	AC Frequency Trip Points (Hz)	
AC Frequency Range:	59.3-60.5Hz	Low: 59.3 +/- 0.1Hz < 160mS	
Power Factor Range:	0.95-1.0	High: 60.5 +/- 0.1Hz < 160mS	
Enclosure Type -	4 Outdoor use	Conforms to UL Std 1741	
S/N:	PV2600BBAF1210100542	Revision 11/07/05	



3157753 Intertek

Manufactured by PV Powered Bend, OR Visit www.pvpowered.com



Do not cover over Nameplate Data



- NEC Violations
 - 110.21
 - 110.22
 - 408.58
 - 422.60





Power Alternating Current





Label Required Point of Connection Article 690.64



Label Required



Point of Connection

Article 690.64

- Connection May Be on the Supply or Load Side of the Service Disconnecting Means
- Disconnecting Means, Dedicated to Source
- Shall Be Marked to Indicate the Presence Of All Sources
- Circuit Breakers
 - Suitable for Backfeed



Label Required

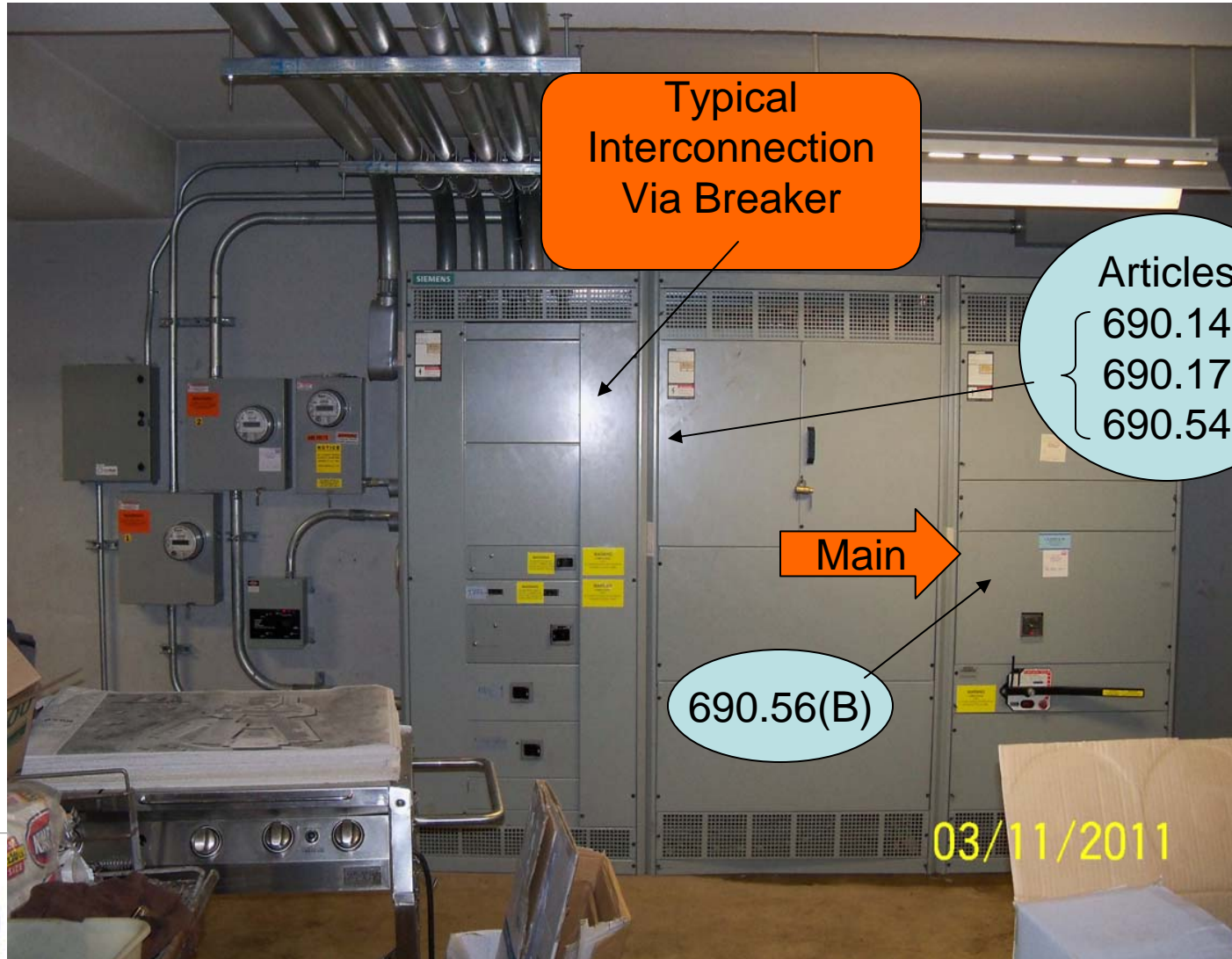
Article 690.54



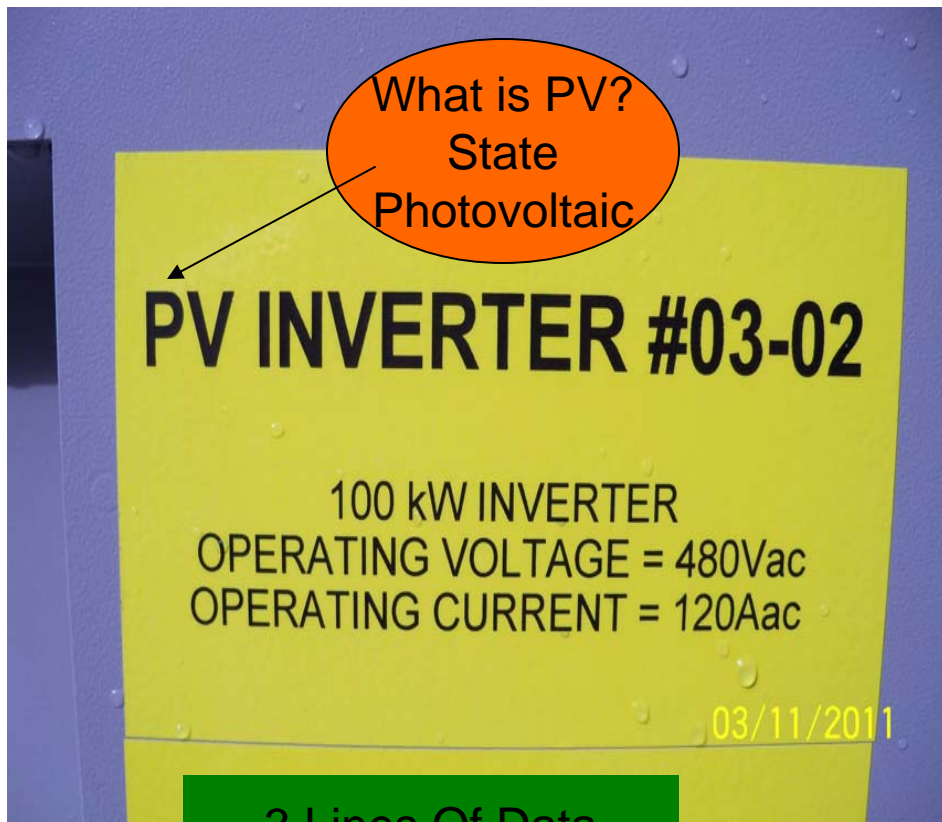
- All Interactive System(s) Points of Interconnection With Other Sources Shall Be Marked
- 3 Lines of Data on AC System
 - Power Source (Photovoltaic)
 - Rated Output Current (Amps)
 - Nominal Operating AC Voltage (120/240VAC)



Service Equipment



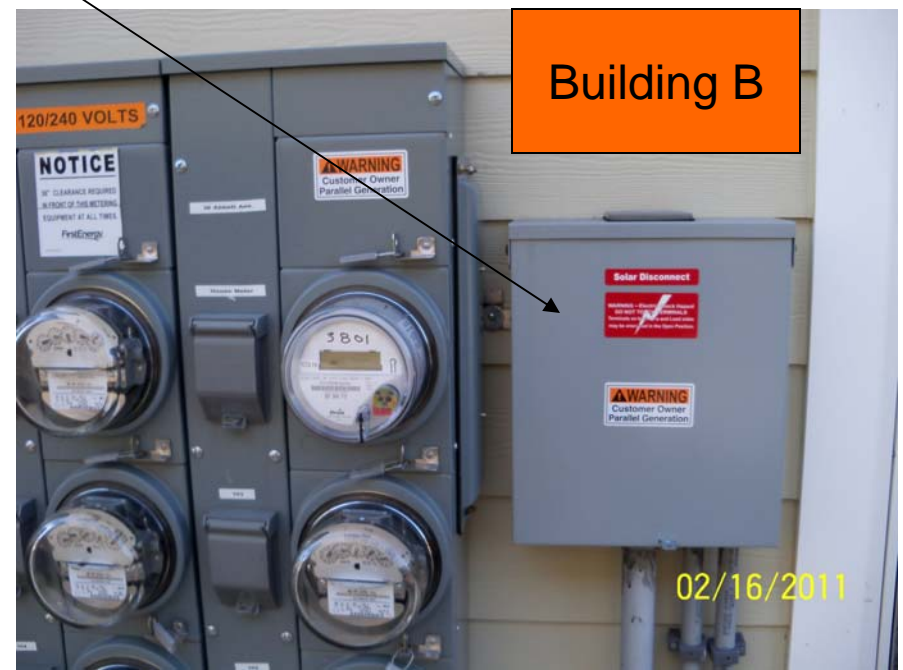
Interactive Systems Breaker Article 690.54



3 Lines Of Data
Power Source
Op. Current
Op. Voltage



Two Buildings, Missing ID 90.56(B)



Label Required

Article 690.56(B)



- Utility Services and PV Systems
- Permanent Plaque or Directory
 - Locations of All Disconnecting Means if Not Located at Same Location
 1. Service Disconnect
 2. Photovoltaic Disconnect(s)



Service Disconnect Location Identified for Safety Personnel



Failure
690.56(B)

Only PV
Disconnect ID
Missing Service
Disconnect
Location



Not an NEC
Requirement

GALVES
AUTO PRICE LIST INC.

INC.

01/18/2011



Service Locations PV and Utility



Pass
690.56(B)



Service Locations PV and Utility





Power Alternating Current



Inverter Output Circuits



Conductors between inverter and service equipment or distribution systems



Circuits Shall Be Identified



- NEC 408.4, switchboards and panelboards
 - Every Circuit shall be legibly marked
 - Shall include sufficient detail
 - Shall be distinguishable from all others
- 110.22, electrical installation
 - Proper Circuit Identification
 - Indicate it's Purpose
 - Marking shall be of Sufficient Durability



Interactive Systems Inverter Output circuit



WARNING
POWER SOURCE 2 OF 4
ALL POWER SOURCES ARE
PRESENT IN THE MAIN ELECTRICAL
PANEL

WARNING
PV INVERTER #11-01
OUTPUT CONNECTION
DO NOT RELOCATE
THIS OVERCURRENT DEVICE

EAST COAST PANELBOARD
Circuit Breaker Rating of this panelboard shall not exceed the rating of any one based on the rating of any branch circuit or rating of any branch circuit. Additional or replacement devices shall be of the same manufacturer, type, description and rated rating.
DANGER
High voltage.
Will cause severe injury.
Keep out.
Qualified personnel only.
Disconnect and lock off all power before working on this equipment.

WARNING
POWER SOURCE 4 OF 4
ALL POWER SOURCES ARE
PRESENT IN THE MAIN ELECTRICAL
PANEL

CIRCUIT BREAKER
PVCB #11-01
PV INVERTER #11-01
AC OUTPUT CIRCUIT BREAKER
OPERATING VOLTAGE = 480V
OPERATING CURRENT = 120Aac

WARNING
PV INVERTER #11-01
OUTPUT CONNECTION
DO NOT RELOCATE
THIS OVERCURRENT DEVICE

WARNING
POWER SOURCE 4 OF 4
ALL POWER SOURCES ARE
PRESENT IN THE MAIN ELECTRICAL
PANEL

CIRCUIT BREAKER
PVCB #11-03
PV INVERTER #11-03
AC OUTPUT CIRCUIT BREAKER
OPERATING VOLTAGE = 480V
OPERATING CURRENT = 62Aac

WARNING
PV INVERTER #11-03
OUTPUT CONNECTION
DO NOT RELOCATE
THIS OVERCURRENT DEVICE

690.14
690.54
690.64

WARNING
ELECTRICAL SHOCK HAZARD
THE DC CONDUCTORS OF THIS
PHOTOVOLTAIC SYSTEM ARE
UNGROUND AND MAY BE
ENERGIZED

MDP-2

690.17

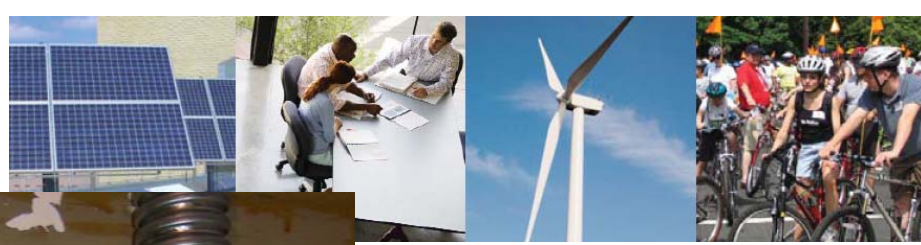
02/22/2011



Inverter Output Circuits



Panel



Missing Identification violation

Covering Mfg. Data violation



Inverter Output OCD Location?



AC Disc.
No Label

- This inverter found in a 6th Floor Mechanical Room.
- Disconnect not identified, NEC 110.22, 690.14, 690.56, 690.64
- NEC 690.54, Were all system interconnection points labeled?



Not Readily Accessible Inverters Under Modules



Label Required

Article 690.14(D)(4)



- Inverters which are not readily accessible
 - See NEC definitions for accessible
 - See NEC 705.10, interconnected power production
 - Permanent Plaque or Directory shall be installed
 - Denoting all electrical power sources
 - i.e. Utility and Photovoltaic Systems on premises
 - Plaques shall be installed @ these locations
 1. Each Service Equipment location
 2. At Locations of ALL electrical power production sources capable of being interconnected.
i.e. inverter output circuits



Inverters Reached Using Ladder



Label Required

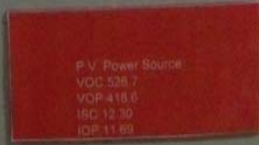
ARC Flash Hazards

NEC 110.16



- Clearly Visible to Qualified Persons
- AC Systems Highest Potential for Burn
- High available inrush currents AIC
- Signage required, other than dwellings





01/14/2011





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Power Direct Current



- Photovoltaic Output Circuit
- Photovoltaic Source Circuit
- Photovoltaic Power Source



Label Required

Article 690.14(C)(2)



- Photovoltaic System Disconnect (actual wording)
 - Optional add the letters DC
 - DO NOT use the acronym PV
- Disconnects inherent to inverter may already have this applied by manufacture.





**CAUTION SOLAR:
ELECTRIC SYSTEM**

**DC DISCONNECT
FOR
PV SUB-ARRAY
COMBINER BOX-A**

WARNING
ELECTRICAL SHOCK HAZARD. DO NOT TOUCH TERMINAL. TERMINALS ON BOTH THE LINE AND LOAD SIDES MAY BE ENERGIZED IN THE OPEN POSITION.

**PHOTOVOLTAIC ARRAY
DC DISCONNECT**

OPERATING CURRENT: 224.37 A
 OPERATING VOLTAGE: 471.12 V
 MAX SYSTEM VOLTAGE: 575.64 V
 SHORT-CIRCUIT CURRENT: 350.02 A

EAT-N Cutler-Hammer
Heavy Duty Safety Switch
 Interrupteur de sécurité à usage intensif
 Interruptor de seguridad de servicio pesado

400 A, 600 V

ON

OFF

DANGER
 HAZARDOUS VOLTAGE. WILL CAUSE SEVERE INJURY OR DEATH.
 TENSION BANDEVIÈRE. PEUT CAUSER DES BLESSURES GRAVES
 EN LA MUERTE

PELIGRO
 ALTA TENSION. PUEDE CAUSAR HERIDAS SEVERAS O LA MUERTE

DANGER
 Electric shock hazard. Do not touch terminals. Terminals on both the line and load sides may be energized in open position.
 Risque de choc électrique. Ne pas toucher les bornes. En position ouverte, les bornes peuvent être sous tension à la fois du côté ligne et du côté charge.
PELIGRO
 Peligro de descargas eléctricas. No toque las terminales. Las terminales tanto en el lado como de los lados de carga pueden estar energizadas aun en la posición abierta.

CAUTION
 COVER SCREWS MUST BE SECURED BEFORE TURNING SWITCH "ON"

AVERTISSEMENT
 S'ASSURER QUE LES VIS DU COUVERCLE SONT BIEN SERRÉES AVANT DE METTRE SOUS TENSION

PRECAUCION
 LOS TORNILLOS DE LA CUBIERTA DEBEN ESTAR BIEN ASEGURADOS ANTES DE ENCENDER EL INTERRUPTOR

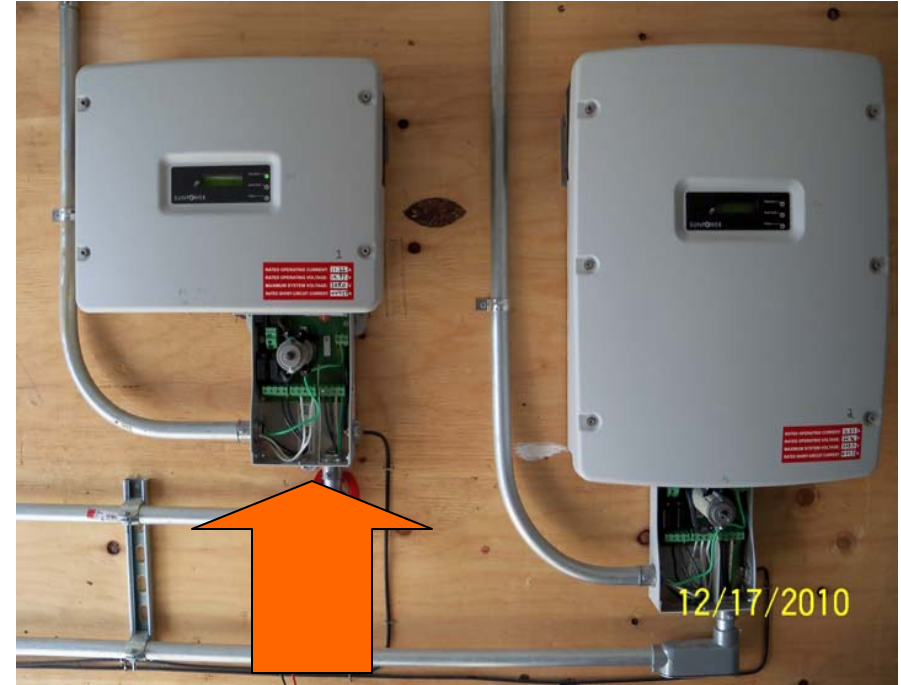
The word **system** eliminated

- PV Power Sources
- Multiple arrays
- Sub array substituted

01/05/2011



DC Disconnects Supplied by Mfg.



Label Required

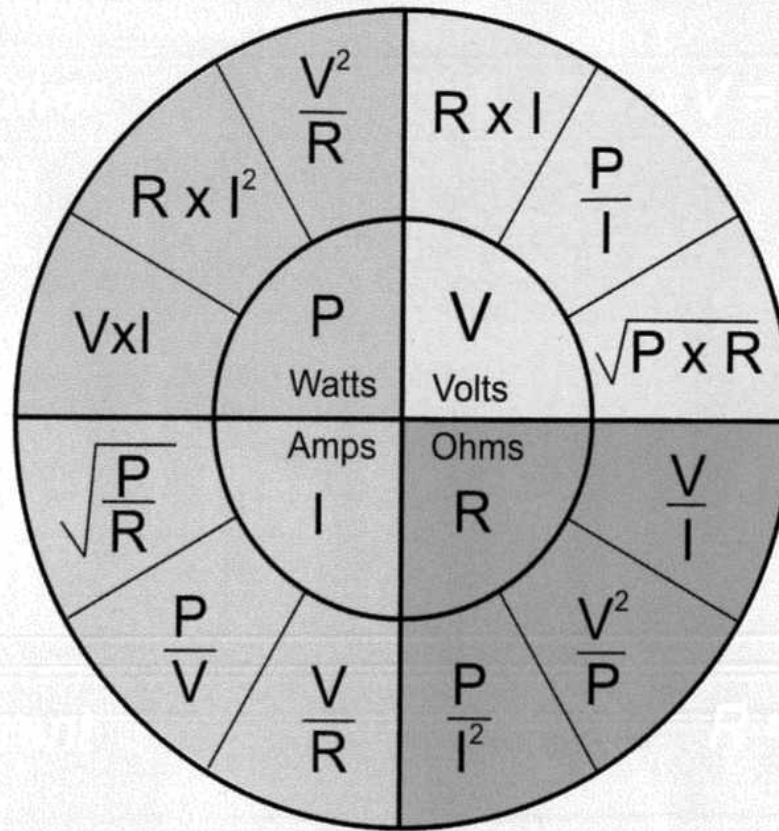
Article 690.53



- DC PV Power Source
- Permanent
- At the PV Disconnecting Means
- Four Lines of data
 - Rated Maximum Power-Point Current (IMP)
 - Rated Maximum Power-Point Voltage (VMP)
 - Maximum System Voltage (VOC)
 - Short Circuit Current (ISC)
- Five lines of data with charge controllers
 - Maximum Rated Output Current of the Charge Controller



Ohms Law



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Located on DC Disconnect



Safety
OK to add
Verbiage

**WARNING : DC VOLTAGE IS ALWAYS PRESENT
WHEN MODULES ARE EXPOSED TO SUNLIGHT.**

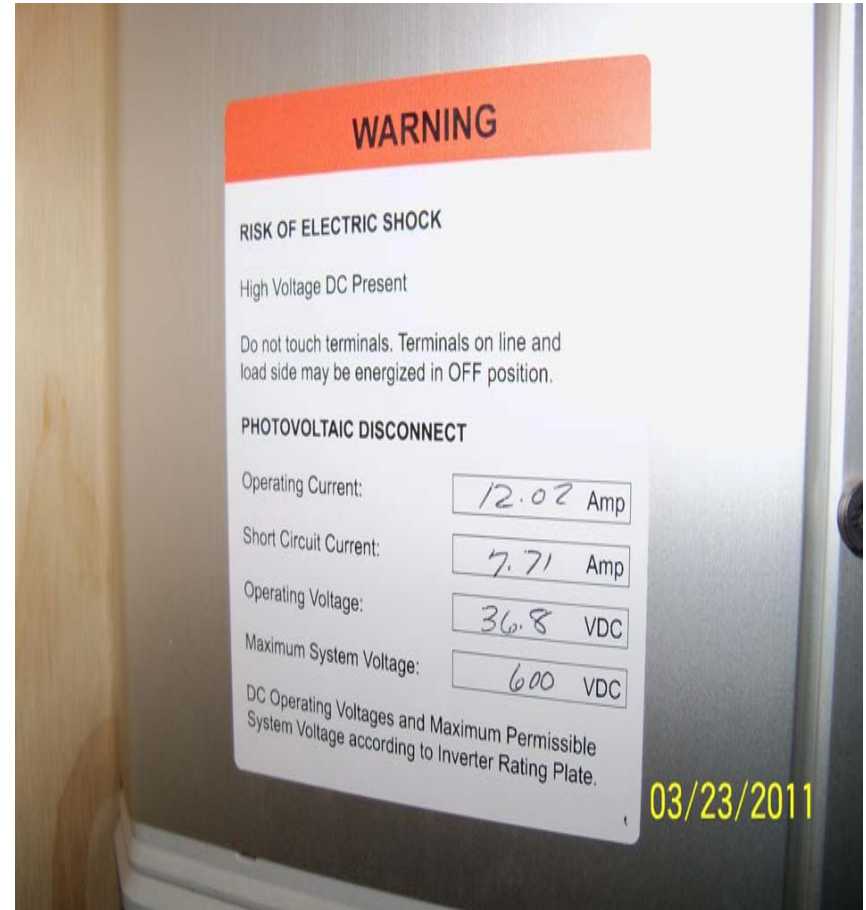
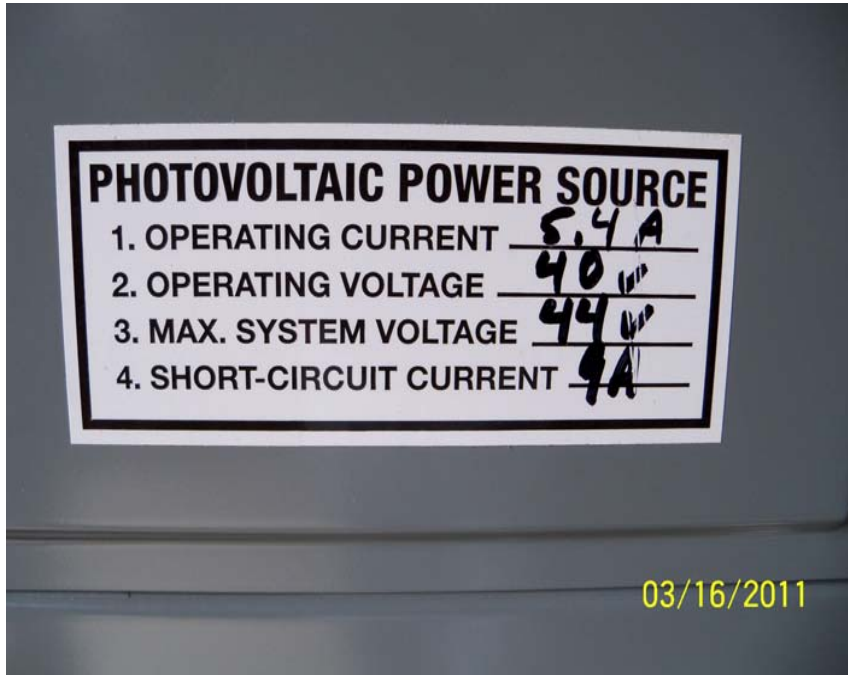
**ARRAY OPERATING CHARACTERISTICS:
OPERATING CURRENT (I_{mp} @ STC) 295 A_{dc}
OPERATING VOLTAGE (V_{mp} @ STC) 460 V_{dc}
MAXIMUM SYSTEM VOLTAGE (V_{oc}) 600 V_{dc}
MAXIMUM SYSTEM CURRENT (I_{sc} @ STC) 25K A_{dc}**

Wire Size?

01/05/2011



Indoors



PV output circuit



- String wiring
- Conductor between modules and inverter or modules to combiner

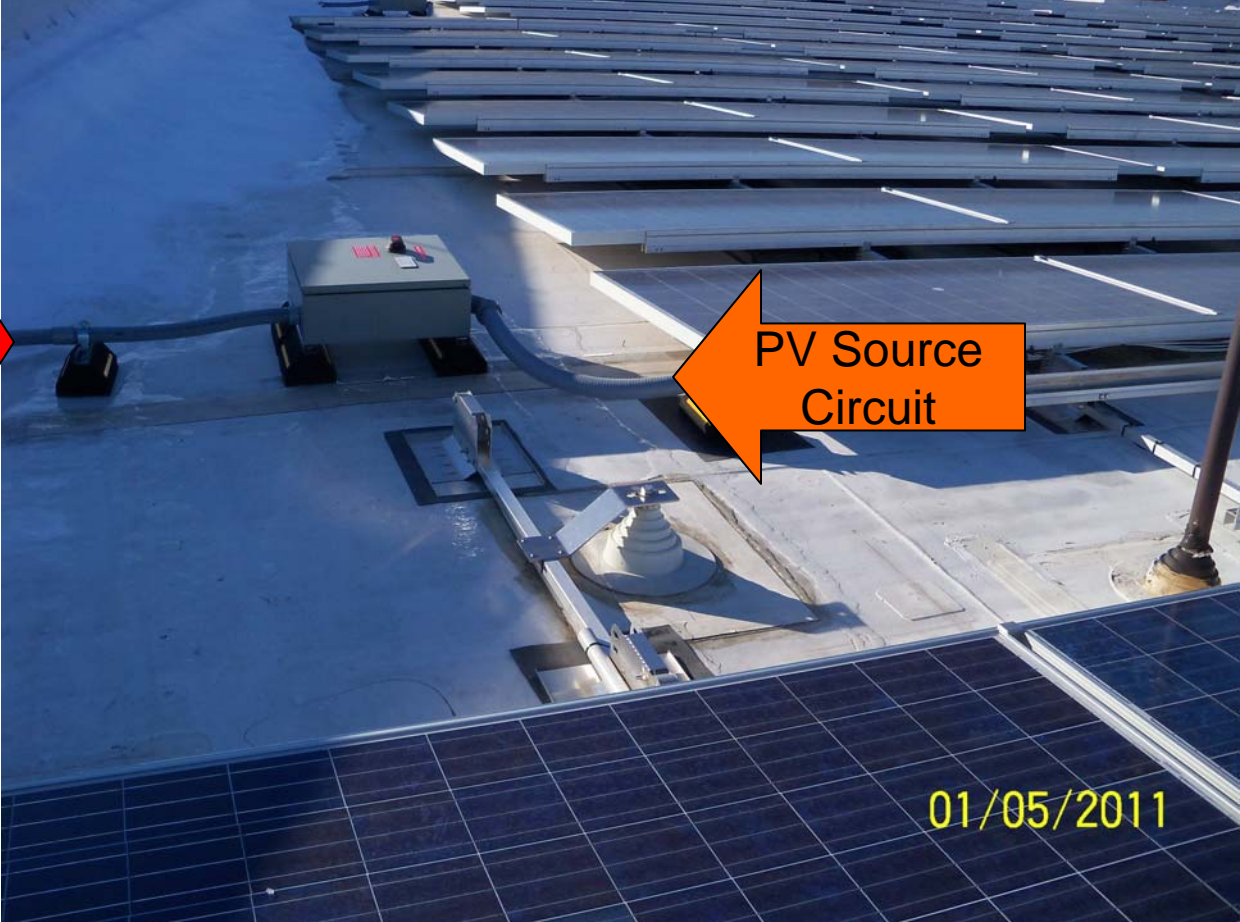


PV Circuit Description



PV Output
Circuit

PV Source
Circuit



PV Power Source



- An array
- Aggregate of arrays (sub arrays)
- Generates DC





Label Required

Disconnects Article 690.17

- Disconnecting Means
- AC and DC
- Permanent
- For All AC and DC Terminals That May Be Energized in the Open Position
 - Warning Label; Don't Touch, Line and Load Energized



Label Required Article 690.17



Optional PV Systems



- Batteries
- Ungrounded Arrays
- BiPolar Arrays
- Stand Alone Systems



Label Required

NEC 690.55



- Batteries
- 3 Lines of Data
 - Maximum Operating Voltage
 - Any Equalization Voltage
 - Polarity of the Grounded Circuit Conductor



Label Required

NEC 690.35



- Ungrounded PV Power Systems
- Wording; Warning Electric Shock Hazard. The Direct Current Conductors of this Photovoltaic System are Ungrounded and May be Energized
- Aurora Inverters
 - Become ungrounded when disconnect opened



Label Required

NEC 690.7(E)



- Bipolar Source and Output Circuits
- Clearly Labeled with the Highest Voltage Between Conductors
- Wording; Warning Bipolar Photovoltaic Array. Disconnection of Neutral or Grounded Conductor May Result in Overvoltage on Array or Inverter



Label Required

Article 690.56(A)



- Stand Alone System
- Not Connected to Grid
- Permanent Plaque and Readily Visible
- Two Lines of Data;
 1. State the Location of the System Disconnect
 2. This Structure Contains a Stand Alone Electrical Power System



AC Modules



Enphase assemblies used as
comparison only

Not Listed as an AC Module

NEC Article 690.52 may be applicable



Enphase Equipment



Label Required Article 690.52



- AC Photovoltaic Modules
- Five Lines of Data
 1. Nominal Operating AC Voltage (240 Volts)
 2. Nominal Operating Frequency (60Hz)
 3. Maximum Power (Watts)
 4. Maximum AC Current (Amps)
 5. Maximum Over Current Device Rating for AC Protection

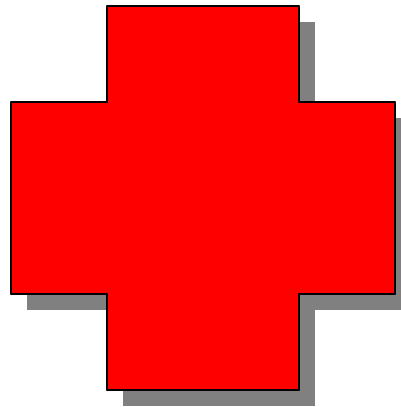


Labeling for AC modules Article 690.52

Location AC Panelboard



Identify Systems for Safety Personnel



Placards placed next to;
Fire alarm panels
Outside Electric meters



Label Required

Article 690.56(B)



- Utility Services and PV Systems
- Permanent Plaque or Directory
 - Locations of All Disconnecting Means if Not Located at Same Location
 1. Service Disconnect
 2. Photovoltaic Disconnect(s)





Next to
Fire Alarm
Panel

For additional
Safety
Include another
@ Outdoor
Utility Meter

THIS BUILDING IS CONNECTED TO A
SOLAR PHOTOVOLTAIC
ELECTRIC SYSTEM.
THE UTILING DISCONNECT IS LOCATED
IN A SUBPANEL ON THE 1st FLOOR
ROOM: SOLAR UTILITY DISCONNECT

03/29/2011





Danger Keep Out!



WARNING
Customer Owned
Parallel Generation
Photovoltaic System
Installed Backfeeding
SubPanel NHP2 in Telco Room
Second Floor IT Room

DANGER
HIGH VOLTAGE
UNAUTHORIZED PERSONNEL
KEEP OUT

 **WARNING**
POTENTIAL ARC FLASH HAZARD
CAN SHOCK, BURN OR CAUSE
DEATH

**CUSTOMER OWNED
PARALLEL GENERATION**

WARNING: ELECTRIC SHOCK HAZARD. DO NOT TOUCH TERMINALS. TERMINALS ON BOTH LINE AND LOAD SIDES MAY BE ENERGIZED IN THE OPEN POSITION

2010/02/22



Ground Fault Detection



- GFDI is Normally Required for All Arrays
- If a ground fault is detected the inverter will internally disconnect all DC wiring (grounded and ungrounded)
- Inverters will have indicators alerting a ground fault
- Manufactures should have proper ground fault labeling



Label Required

NEC 690.5(C)



- Ground Fault Protected Equipment
- Normally Applied by Manufacture
- NEC States
 - Warning Electric Shock Hazard If A Ground Fault Is Indicated, Normally Grounded Conductors May Be Ungrounded And Energized





Photovoltaic Systems

Site Photos





Roof top Photovoltaic System

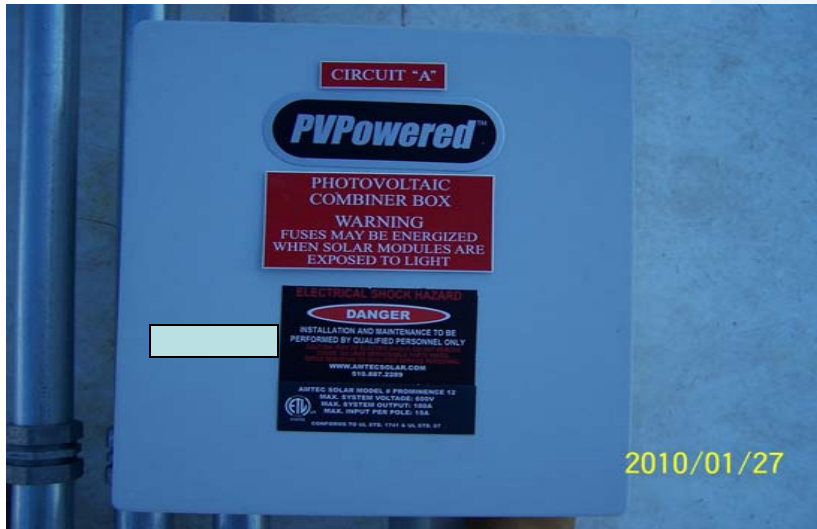


DC
Conduits
Identified

2010/01/29



Combiner Boxes



Disconnects



2010/01/21



2010/01/27



2010/01/21



2010/02/04





Resources for Labeling

- Manufactures Supplied with Inverters
- www.altestore/store/info/products-enclosures_electrical and safety-nec compliant labels
- Ideal Company
- Grainger
- Trophy Shops
- Internet



Summary



- Use only listed and labeled equipment
- Apply labeling as per NEC
- Keeps Unqualified Persons Out
- Properly Calculated Label Help the Wiring Inspector Verify Wiring Utilized
- Safety and efficiency are primary concerns
- MM Hand Out for Reference

