Inspector Training Workshops
Module One
Photovoltaic Labeling based on 2008 NEC

NJCE Market Manager
HW Construction Department
Wayne, NJ
Robert A. Menist

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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

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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

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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!

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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

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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

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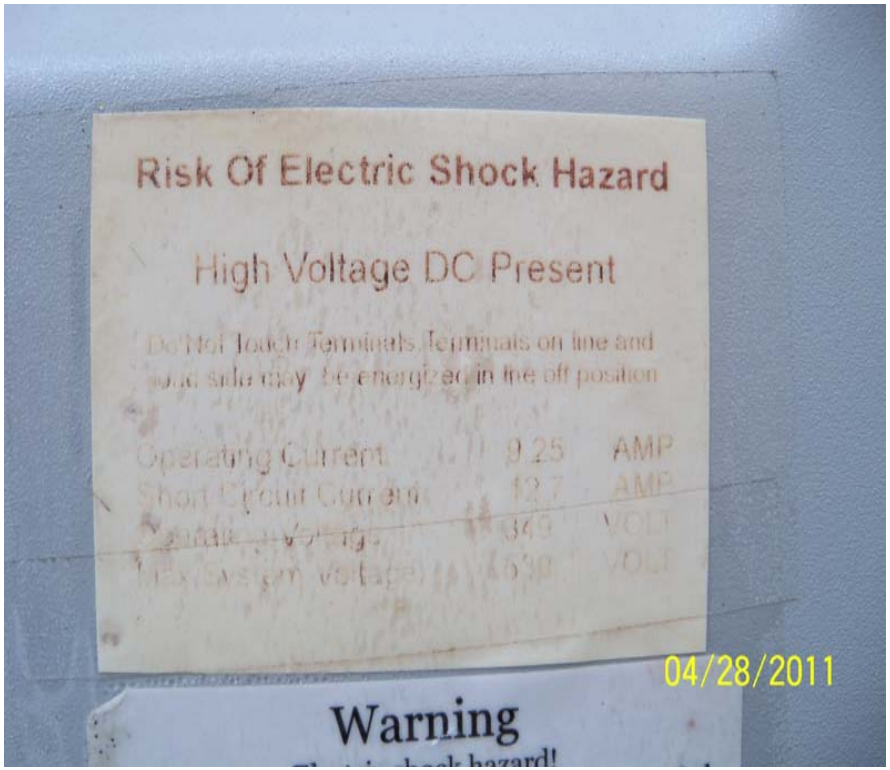
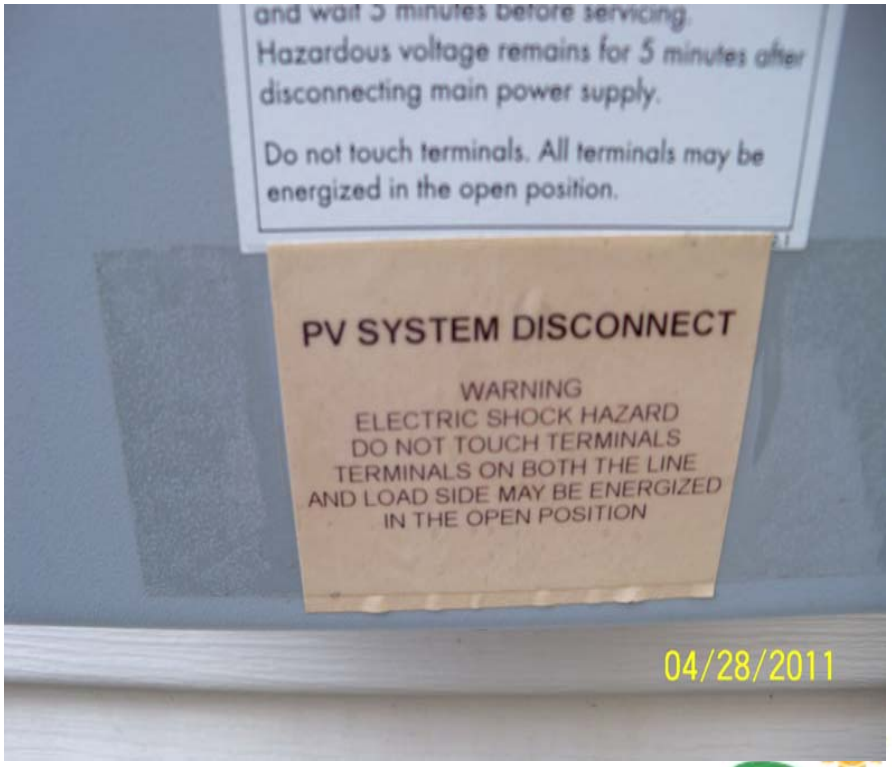
Are these Outdoor Rated?





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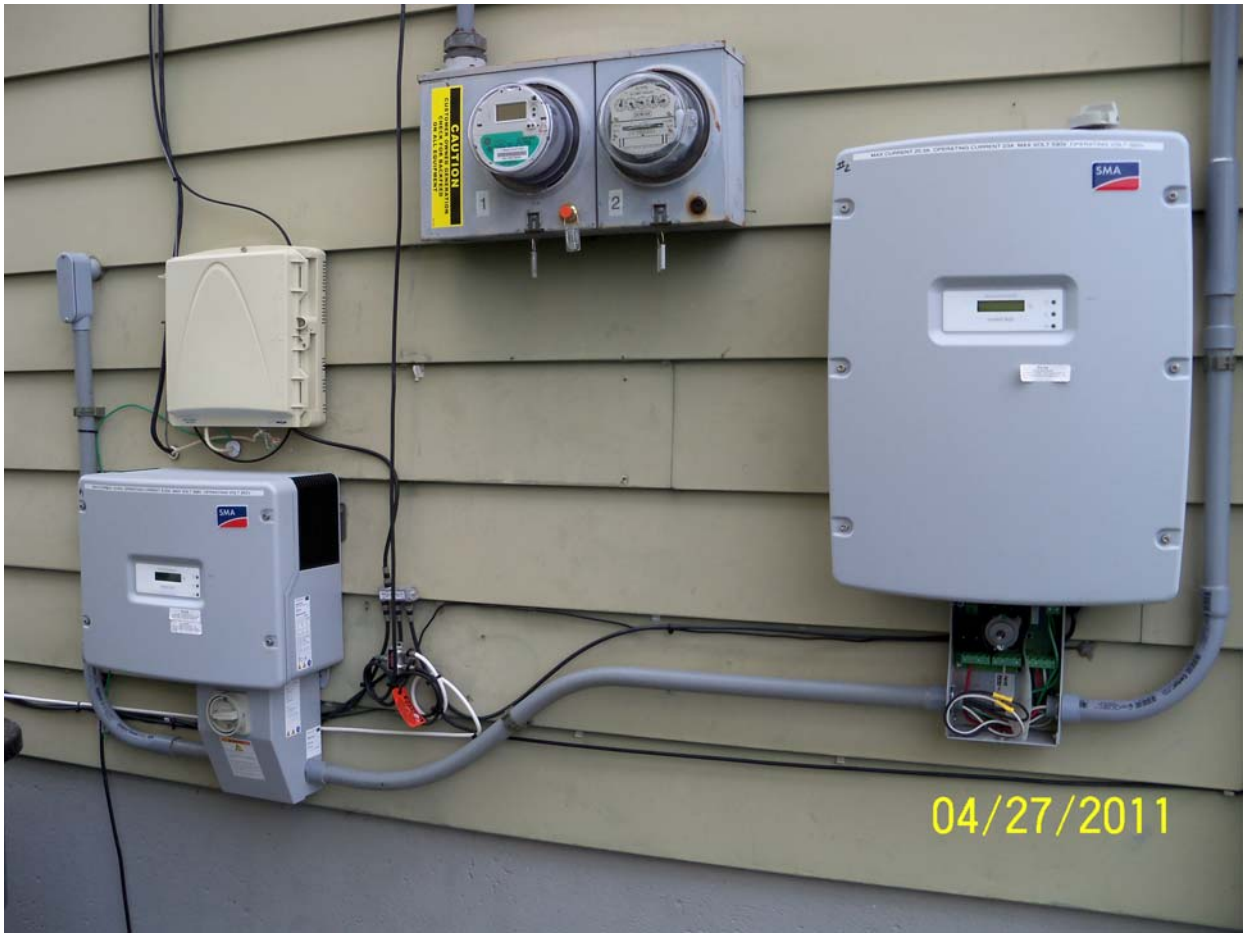
Paper, poor choice



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Paper doesn’t last

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Manufactures Nameplate Information

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Equipment Nameplates

Inverter

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Do not cover over Nameplate Data

- NEC Violations
  - 110.21
  - 110.22
  - 408.58
  - 422.60

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Power Alternating Current

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Label Required
Point of Connection
Article 690.64

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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)

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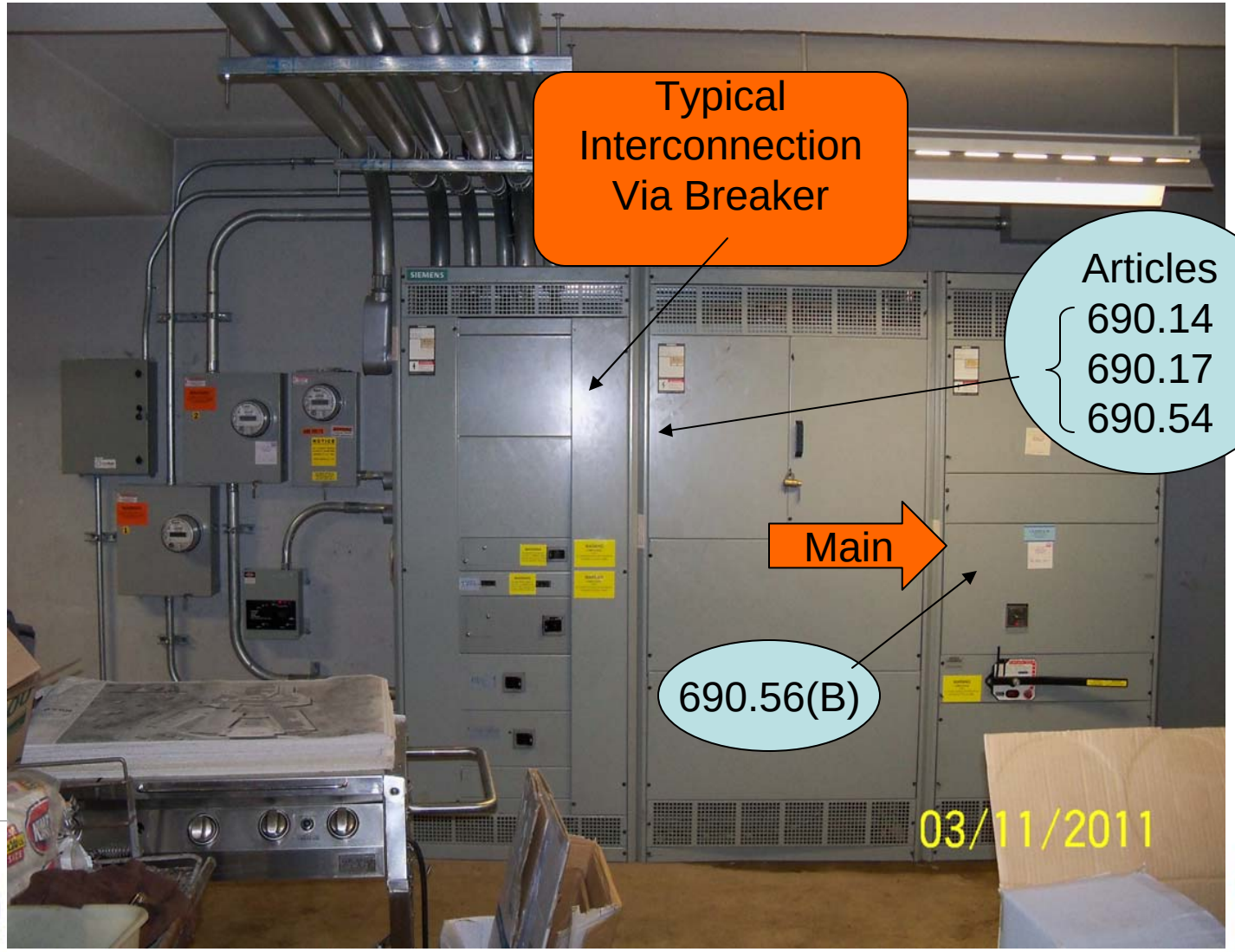
Service Equipment



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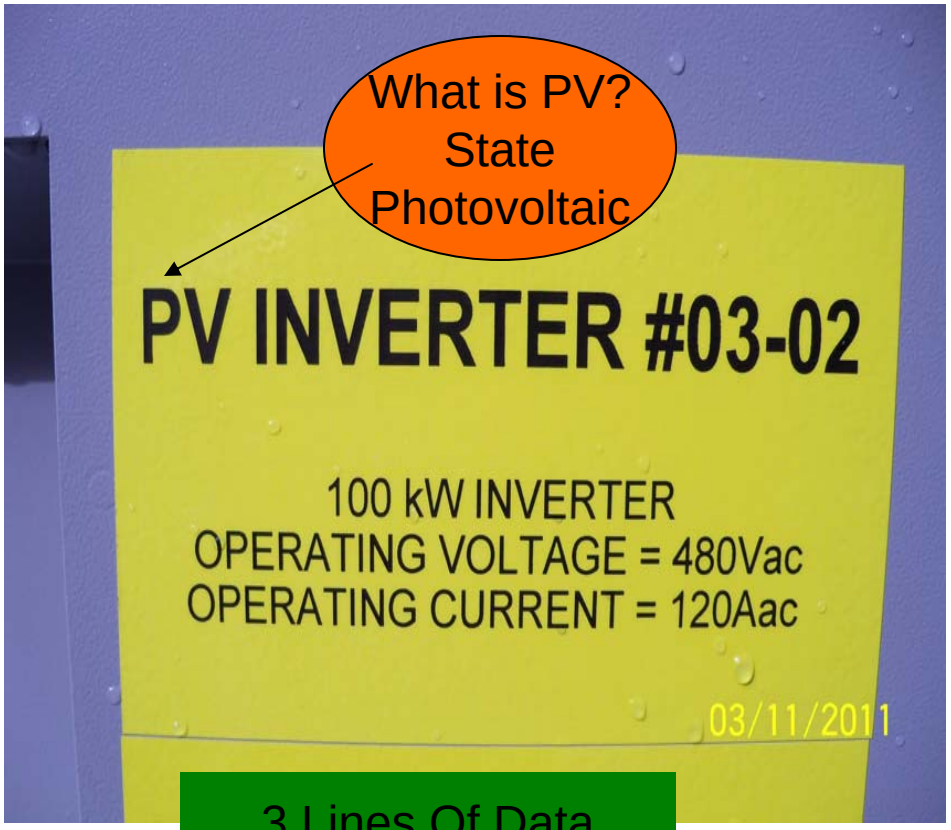
Interactive Systems
Breaker Article 690.54



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

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Two Buildings, Missing ID 90.56(B)

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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

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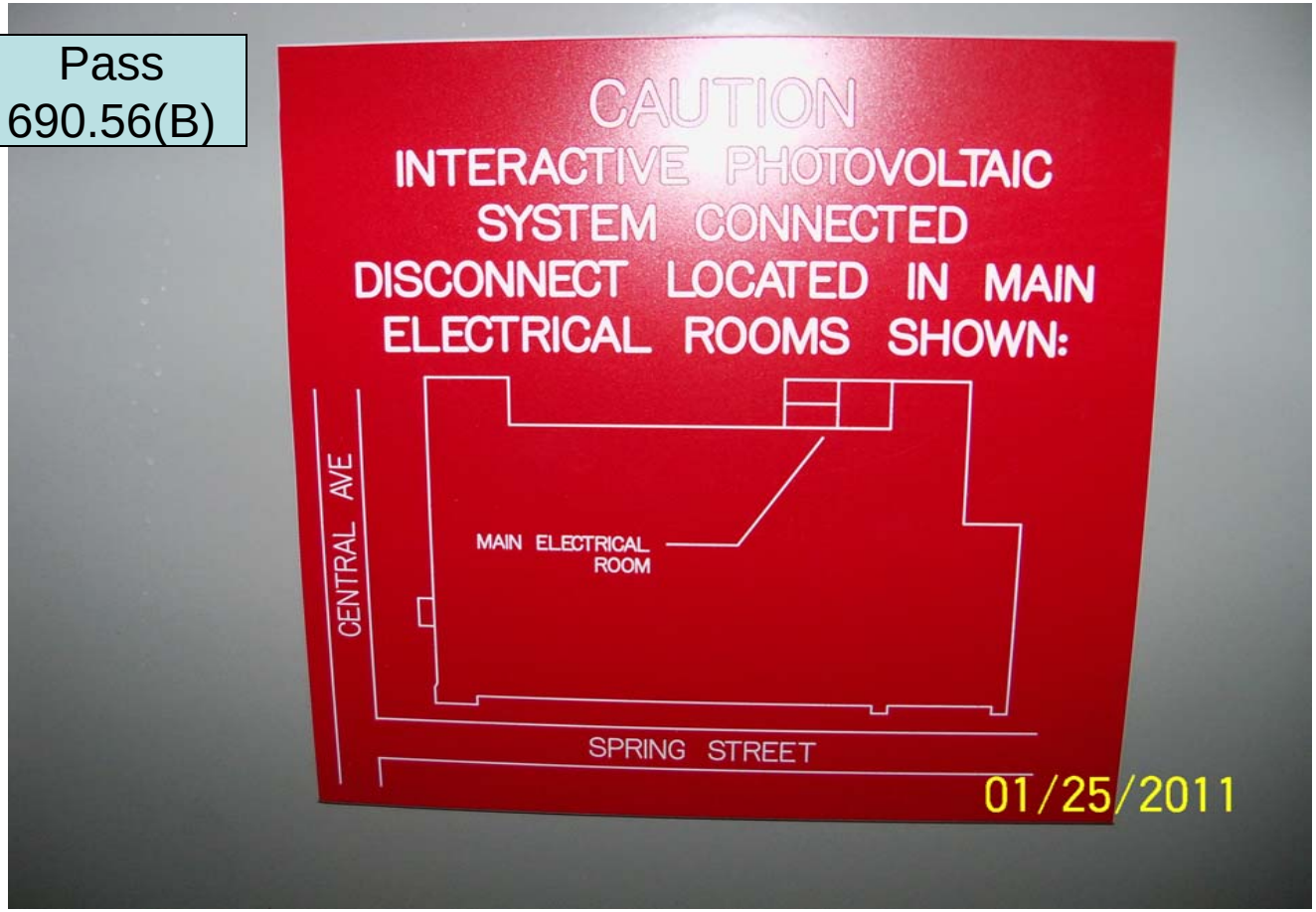
Service Locations PV and Utility

Pass
690.56(B)



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Service Locations
PV and Utility

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Power
Alternating Current

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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

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Inverter Output Circuits

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Panel

Missing Identification violation

Covering Mfg. Data violation

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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?

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Not Readily Accessible Inverters Under Modules

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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

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Inverters Reached Using Ladder

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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

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SMA SOLAR TECHNOLOGY

SUNNY BOY

DANGER

Arc flash hazard!
Follow requirements in NFPA 70 E
for safe work practices and appropriate
PPE. Failure to comply can result in
death or injury!

IDEAL INDUSTRIES, INC. Cat. No. 44-895

Overall System Parameters
Operating AC Voltage: 120/208V
P.V. Array Rating: 4,945WDC at STC
P.V. Array Rating: 4,475WDC at PTC

P.V. Power Source:
VOC:536.7
VOP:418.6
ISC:12.39
IOP:11.69

01/14/2011

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Power
Direct Current

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

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Label Required
Article 690.14(C)(2)

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

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The word system eliminated

- PV Power Sources
- Multiple arrays
- Sub array substituted

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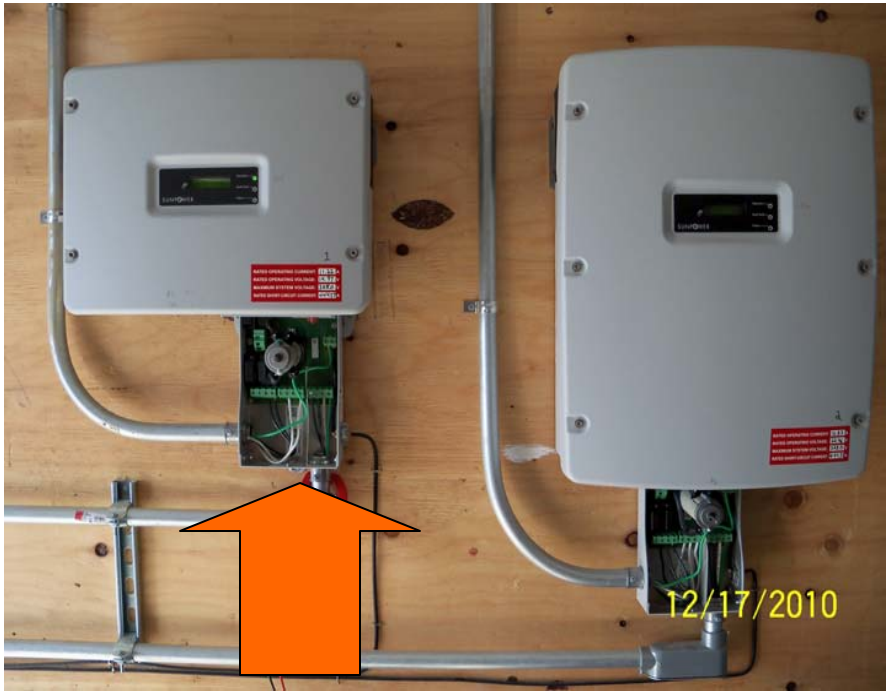
DC Disconnects Supplied by Mfg.



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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

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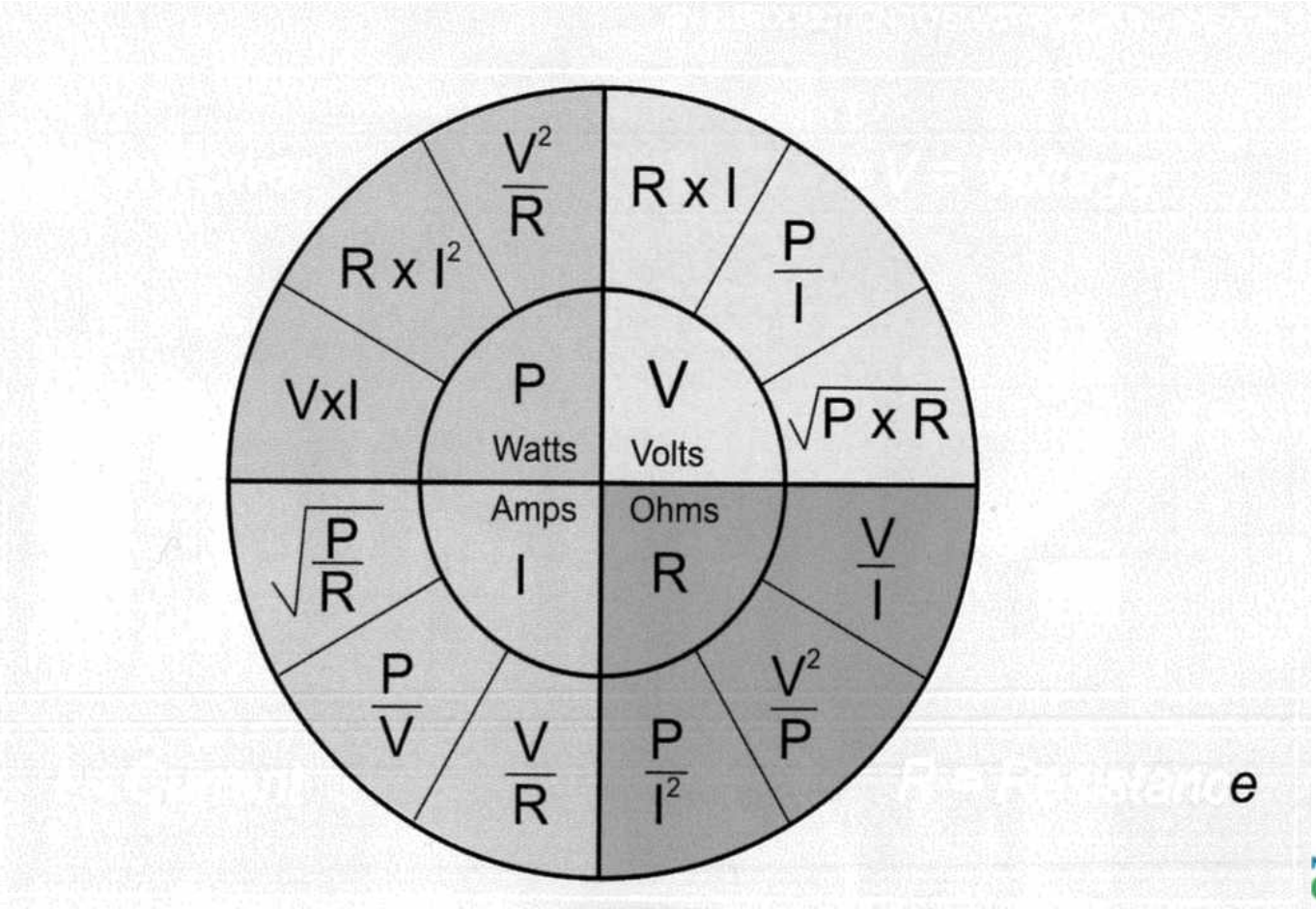
Ohms Law



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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 (Imp @ STC) 295 Adc
OPERATING VOLTAGE (Vmp @ STC) 460 Vdc
MAXIMUM SYSTEM VOLTAGE (Voc) 600 Vdc
MAXIMUM SYSTEM CURRENT (Isc @ STC) 25K Adc

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Wire Size?

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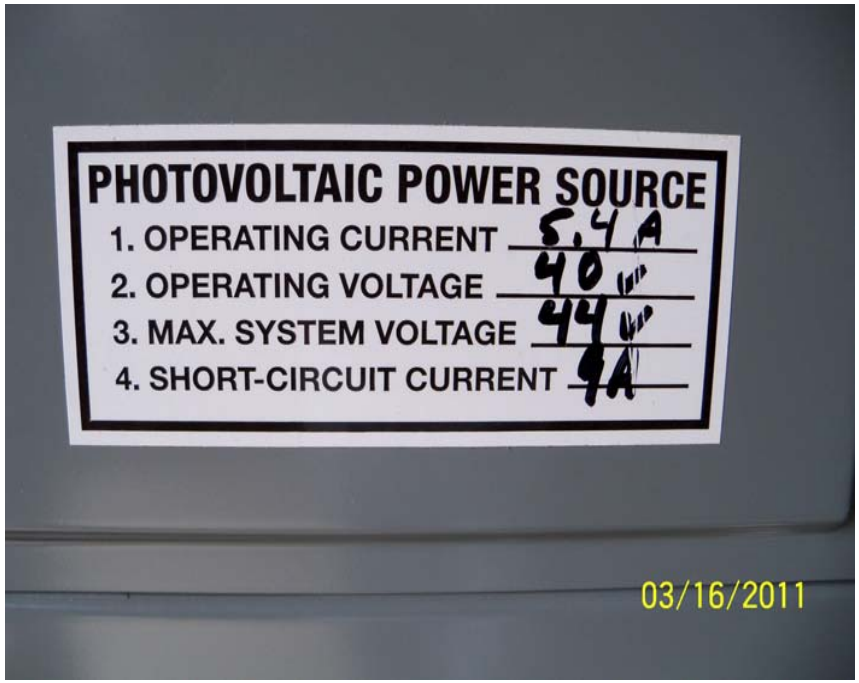
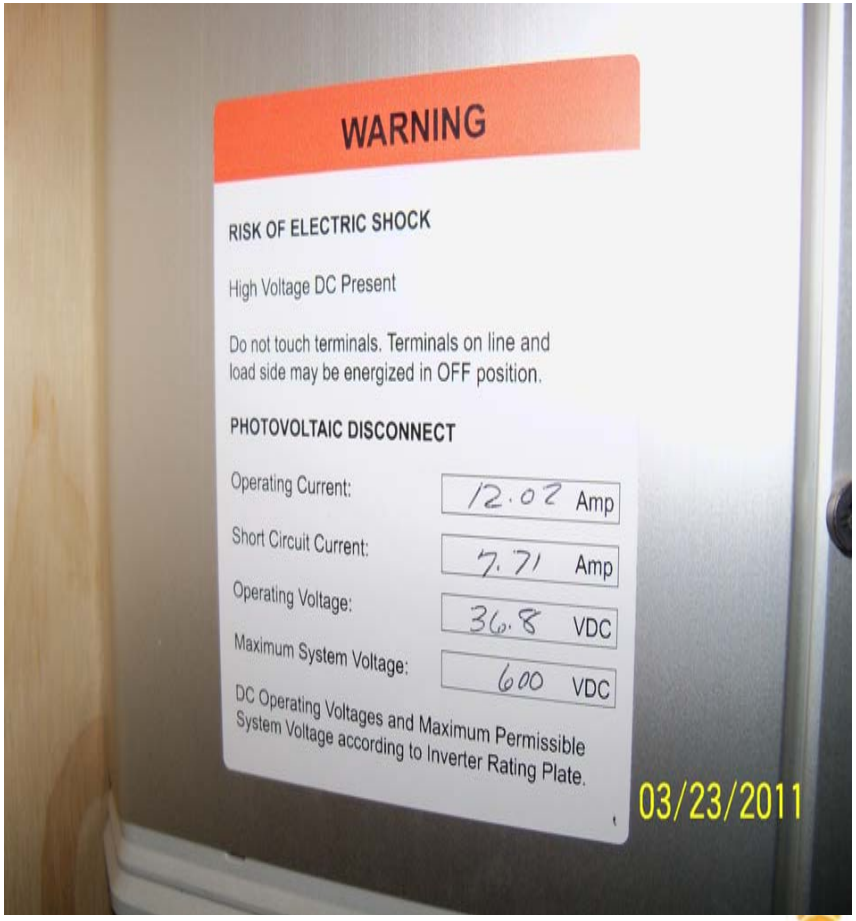
Indoors





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PV output circuit

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

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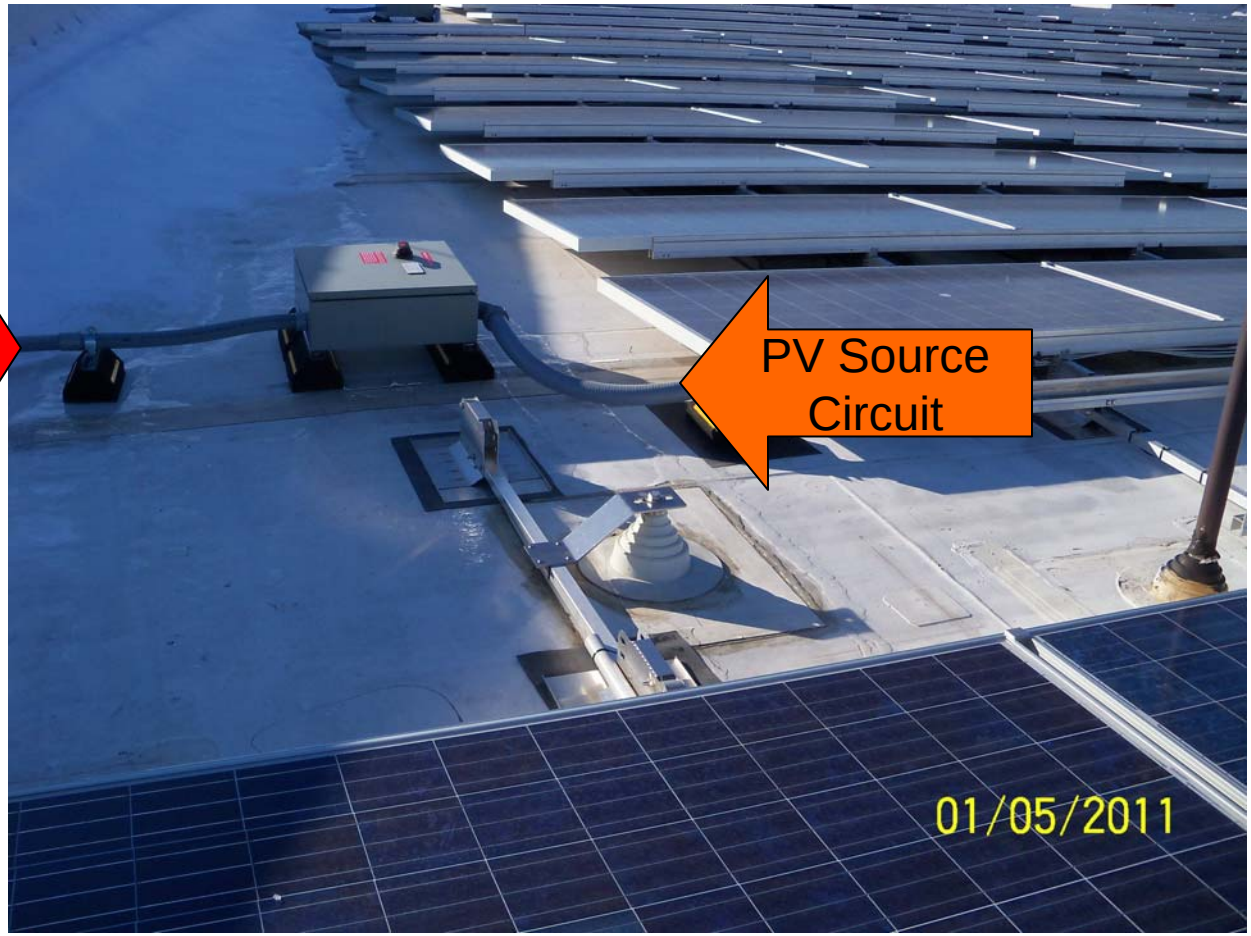
PV Circuit Description



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PV Power Source

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

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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

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Label Required

Article 690.17

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Optional PV Systems

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

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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

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AC Modules

Enphase assemblies used as comparison only

Not Listed as an AC Module

NEC Article 690.52 may be applicable

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Enphase Equipment

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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

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Identify Systems for Safety Personnel

Placards placed next to;

Fire alarm panels

Outside Electric meters

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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)

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Next to Fire Alarm Panel

For additional Safety Include another @ Outdoor Utility Meter

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Danger Keep Out!

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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

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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

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Photovoltaic Systems

Site Photos

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Roof top Photovoltaic System

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Combiner Boxes

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Disconnects

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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

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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