

PV Safety Issues: Key to a Reliable, Viable Industry

Tim Townsend, Sr. Mech. Engr.
BEW Engineering, San Ramon, CA

April 1, 2008

Accelerated Aging in PV Workshop II

The logo for BEW Engineering, featuring the letters 'BEW' in a bold, white, sans-serif font inside a black rectangular box. A yellow circular graphic element is partially visible behind the box on the left side.

BEW

Safety in context: Today's outline

- Our overlap with reliability and availability
- Safety fundamentals and PV
- Contemporary perspectives on PV safety



1: Safety's overlap w/reliability and availability

- The overlap with reliability and availability is clear
- Except when you're not thinking about it
- Safety-based Codes and Standards promote but do not ensure high performance
- **Safety is Prerequisite** to both R and ψ
 - "Safety has priority over service continuity, equipment damage or economics" - *IEEE*
 - "Safety First!" - *your mom*



1: Safety overlap- reliable meets viable

- Safety information is out there
 - Are we teaching it (yes)
 - Are we heeding it (mostly)



- PV “Not young, not old; but a viable, die-able age”
(w/apologies to author A. Roy)

B-W

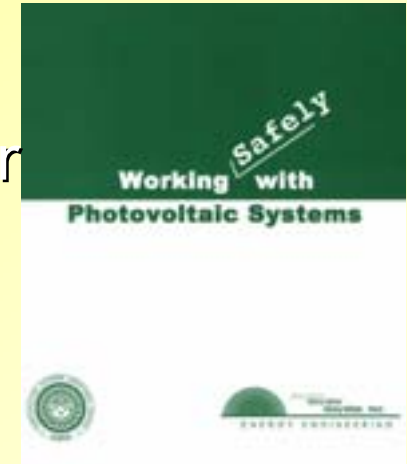
Topic 1: Overlap

- Overlap with reliability and availability
 - The ORF, or Operating Reliability Factor, was authored by a different A. Roy. (Lakewood, CO '89). It is a dimensionless measure of both R and ψ .
 - ORF and/or the similar Performance Index, PI, answer the all-important “did I get what I expected?” Other common yardsticks don't.
 - Hard to measure safety.
 - Easier to measure un-safety. Un-safety causes extended shutdowns. Big PV systems are down today because of it. It affects system economics in direct \$\$ and perhaps 4-8 times more in indirect \$\$ (Bussman guide, 1998)



Topic 2: Safety Fundamentals

- Education
 - “Working Safely With PV” Sandia/Daystar
 - Bussman Safety Basics
 - IBEW training; others cover safety, too
 - Wiles: “Recommended Practices”
 - CPR training and refreshers
 - Proper PPE
- Codes and Standards
 - OSHA: 29 CFR, Parts 1910, 1926, subs e.g. LOTO 1910.147
 - NFPA70 (NEC): esp. Sec 690.
 - IEEE, IEC, ANSI, ASTM, NESC, UL (& NRTLs), NEMA



Topic 2: Safety Fundamentals

- Electrical Safety
 - Shock (dc and ac thresholds vary; 10ma lethal)
 - Arc (burn susceptibility)
 - Blast (vapors, impact injuries, hearing damage)
- Non-electrical Safety
 - Heat/Sun (UV, dehydration, heat exhaustion)
 - Cold (hypothermia)
 - Falls/Impacts (wind loads less well understood than grounding)
 - Bites
 - Conditions are inhospitable, subjecting installers to near-homeless stresses. The work is repetitive and it can be difficult to stay alert.



Topic 2: Safety Fundamentals

- Safety issues arise
 - During design
 - During installation
 - During servicing
- Design:
 - Codes and Standards (minimums...not design guides)
 - Constructability and serviceability (e.g., NEC does not require rooftop dc disconnects)



Topic 2: Safety Fundamentals

- Installation:
 - Need vigilance and commitment to overcome cultural and traditional barriers
 - El Nuevo - expanding industry, unfamiliar staff
 - But it's cloudy out
 - It's only dc
 - El Macho - grade school posturing, now w/real Tonka Toys
 - El Dinero - pressure to just get it done is pervasive
- Servicing:
 - Buddy system, procedures, equipment
 - Need Code-compliant *permanent* labeling
 - Need accurate as-builts



Topic 2: Safety Fundamentals

- Tools:
 - Multimeter, megger, hot stick, cell phone, fire extinguisher for Class C fires, Listed torque drivers
- PPE:
 - Helmet, gloves, footwear, harness, eye protection, face shield, gauntlets, Nomex as applicable



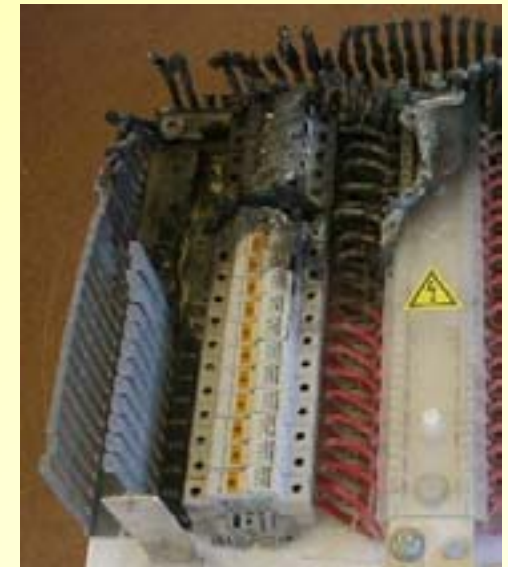
Topic 3: Contemporary Perspectives

- PV's safety history is pretty good
 - As far as we know (see El Macho on previous)
 - No deaths?
 - Relatively few injuries
 - PVUSA experience helped prompt closer attention
 - UL 1703 and 1741 have improved safety
 - However, enough close calls and recurring installation flaws to warrant renewed emphasis



Topic 3: Contemporary Perspectives

- Recent issues
 - Roofs have had burns (several occasions)
 - Structures have failed
 - Connections, fuses, boxes have failed



B-W

Topic 3: Contemporary Perspectives

- Modern hurdles to safety
 - Some 600 V disconnects not load-break rated
 - Mistaken use of 600 Vac/300 Vdc fuses in 600 Vdc locations
 - Licensed electricians not willing to use torque wrenches, adamant about the darn-tight rule
 - Single-phase installers installing 3-phase equipment (single phase, wire(s) in separate conduits)



Topic 3: Contemporary Perspectives

- Modern hurdles to safety
 - Designers' disdain for NEC 690-8 (156% Isc)
 - Electrical gloves are not stylish enough
 - Inspectors are not uniformly trained well enough to enforce NEC compliance
 - Schools (at least in CA) have a diminished AHJ role and PV vendors don't always follow best practice
 - 600 Vdc fuse susceptibility to reverse wiring and 1,200 Vdc arcing at very low currents. Arcing, at voltages and currents within the design ratings of the components is seen to be an issue of increasing importance (<http://labs.ti.bfh.ch/index.php?id=2125&L=2>); Fire hazard from shorted panels to metal and even non-metal roofs



Topic 3: Contemporary Perspectives

- Modern hurdles to safety
 - Grounding is dismissed as overkill. Part of the problem is the ambiguity of the requirements, and 2008 NEC is not any better.
 - Laborers are not trained extensively and more prone to burn-out and accidents
 - Improper footwear
 - Improper other PPE for handling glass and heavy equipment
 - Roof leak tests are standard before turnover but dc circuit checks are not necessarily done first
 - Reluctance to conform to NEC wire color coding
 - Theft and vandalism are safety issues, and PV is vulnerable: visible wires, simple mountings.



ALL ABOVE-CITED ITEMS OCCURRED IN 2007!

Topic 3: Contemporary Perspectives

300 Vdc fuse, strangled negatives, unmarked negatives. What's a service person to do?

Sorry, even positive ground modules can't do this!



PV Safety Issues: Conclusion

- Industry viability is absolutely dependent on safety, and we are doing pretty well
 - In design
 - In installation
 - In maintenance
- Viability requires vigilance
 - Commitment from management
 - Commitment from field staff
 - Training and supervision

