2005 NEC, STANDARDS, AND THE REAL WORLD

INVERTERS, INVERTERS EVERYWHERE BUT SYSTEM ACCEPTABILITY NEEDS IMPROVEMENT

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System Reliability/Durability?

- **2002 IEEE Paper—Inspections, Tests, Informal Surveys**
  - Inverters Rushed to Market with Inadequate Testing
  - Installer/User UNfriendly Inverters and Systems
  - Poorly Written Inverter Instruction Manuals
  - Uninformed Systems Designers
  - Uninformed Systems Installers
  - Uninformed Electrical Inspectors

- **2004—More of the same**
  - 2005 NEC—Minor Improvements
  - UL 1741—Changes, but…

CODES AND STANDARDS CAN HELP…….

CODES AND STANDARDS ARE NOT THE ONLY ANSWER !

INVERTER MANUFACTURERS CAN MAKE SIGNIFICANT CONTRIBUTIONS

- Designs- Know and follow Codes and Standards
- Manuals
- Testing
- Training
- Follow Up

WHY?

TO REDUCE COSTS

- When inverters don't perform or fail…
- When the instructions are unclear…
- When the inverters are hard to install…
- When the user has questions…

Then…

- The Inverter Manufacturer gets to hire a **VERY LARGE** Customer Support Staff at $$$$$$$.

HOW?

- Appoint a Codes/Standards/Systems person
  - Join IAEI
  - Apply for STP UL1741
  - Participate in the NEC/PV Industry Forum
- Understand and apply the requirements of the *NEC (Handbook)* and appropriate UL Standards
- Consult a master electrician
- Finalize the electrical design **before** specifying the mechanical hardware
- Realize that international standards are different

DESIGN

- Electrical Configuration
  - Clearly Specified Input and Output Currents
    - Steady State and Maximum
  - Properly Designed Terminals
    - Sized for Currents
    - Enlarged for Voltage Drop/Rise Considerations
    - Marked for Temperature Limitations
    - Equipped for Multiple Conductor Paralleling
  - Sufficiently Large Wire Bending Space
    - Enlarged to Address Voltage Drop/Rise

DESIGN

- Mechanical Configuration
  - Access from Front
  - Conduit Openings at Electrical Industry Standard Positions/Distances
  - Robust Mechanical Fittings
  - Robust Electrical Terminals
  - More than Minimum Wire Bending Space
  - Designed/Tested Shipping Container


GE Contractor Kit

DESIGN

- User Interface
  - Is it ON?
  - How much power?
  - Other information is of less importance
  - Avoid confusion at all costs
  - KISS works!

DESIGN

- Installer Interface
  - Allow Troubleshooting
  - Provide Separate Levels of Access to Details
  - Make it Difficult to Access Higher Levels

MANUALS

- Separate Installer and User Manuals

- Users get only what they need to know
  - Instructions for turning ON and OFF
  - Instructions for determining if the inverter is ON
  - Instructions for determining inverter output
  - Appropriate Warnings for Safe Operation
  - Possible Theory of Operation Appendix
  - KISS

MANUALS

- Installer (Designer) gets sufficient information to avoid a call to the factory
  - Theory of Operation
  - Mounting Instructions for Multiple Surfaces
  - Electrical Instructions
    - Don't attempt to cover the *NEC*—liability issues
    - Do specify inputs in PV/*NEC*-related terms
    - Do specify inverter conductor sizes and types
    - Do specify external overcurrent devices
    - Do specify applicable conduit types
    - Do specify voltage drop/rise requirements

TESTING

- In-house/Overseas Testing Insufficient
- Adopt Sandia Inverter Testing Protocol
- Lengthy Alpha and Beta Testing Required
  - All Configurations
  - Widely Varying Locations
  - Varying Levels of Installer Competency
  - All Modes Exercised
  - Accelerated Life Cycle Testing

TRAINING

- Factory Training Program—A Must
  - Two to Three Days Minimum
  - Basic Electrical Theory
  - Basic Codes
  - System Design *Implications*
  - Hands-on Installation Training
  - Realistic Troubleshooting

FOLLOWUP

- Contact Distributors/Dealers/Installers
  - Before they contact your **VERY LARGE** customer support staff
  - Ask what works/doesn't work
  - Solicit feedback on a regular basis
  - Implement the suggestions

SUMMARY

- "Those who cannot remember the past are condemned to repeat it." (George Santayana, 1905)
- Invest the time and $$$ before shipping that first customer unit.
- May your Customer Support Staff be

Very Small