the standard in safety

Safety Concerns with New PV Polymeric Materials

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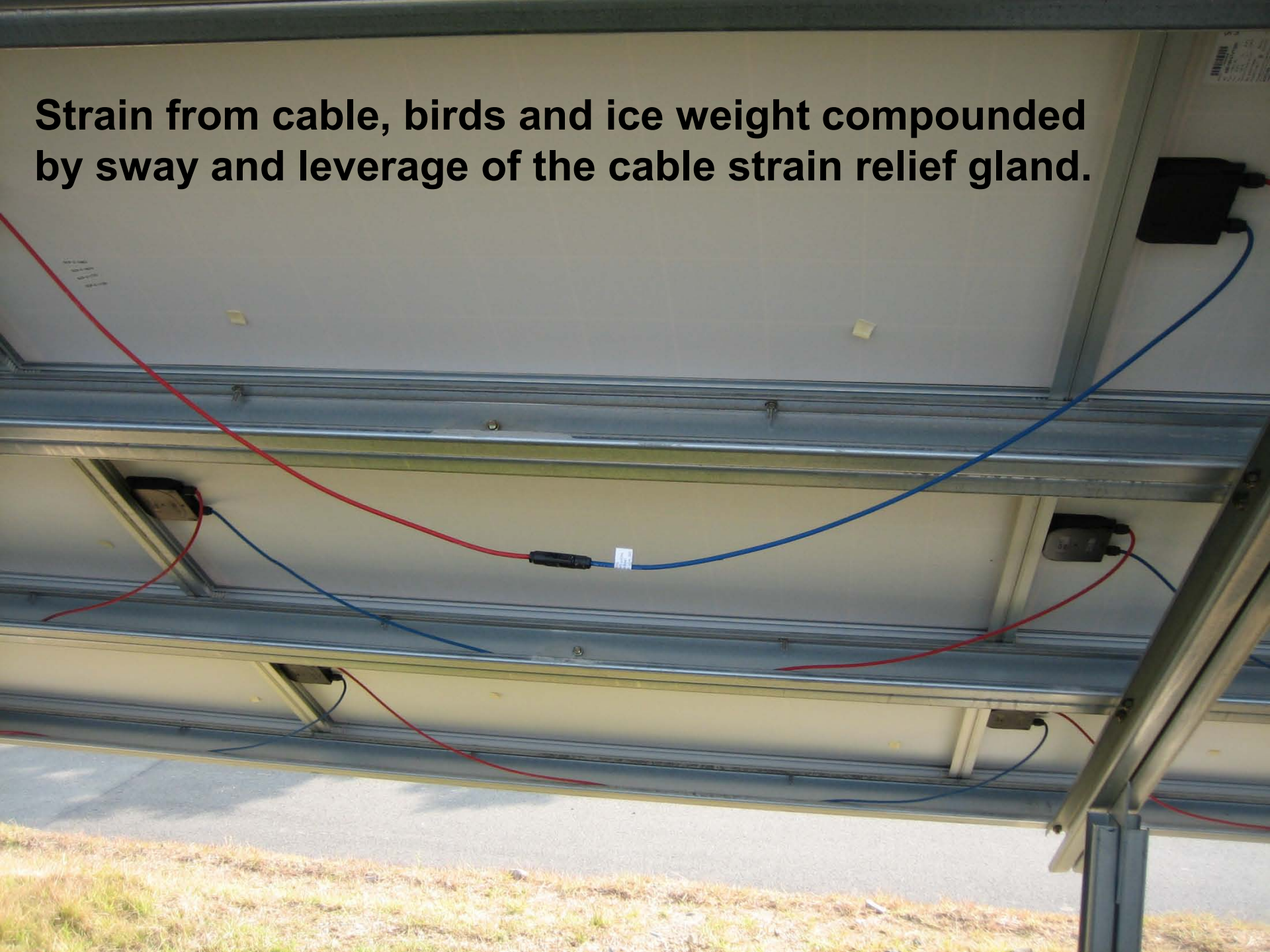
Connector Materials

This passed qualification test.
This is after 8 years operation in AZ

Underwriters Laboratories

This could happen to any PV connection or connector that is unmated under load. 150Vdc and 6A.

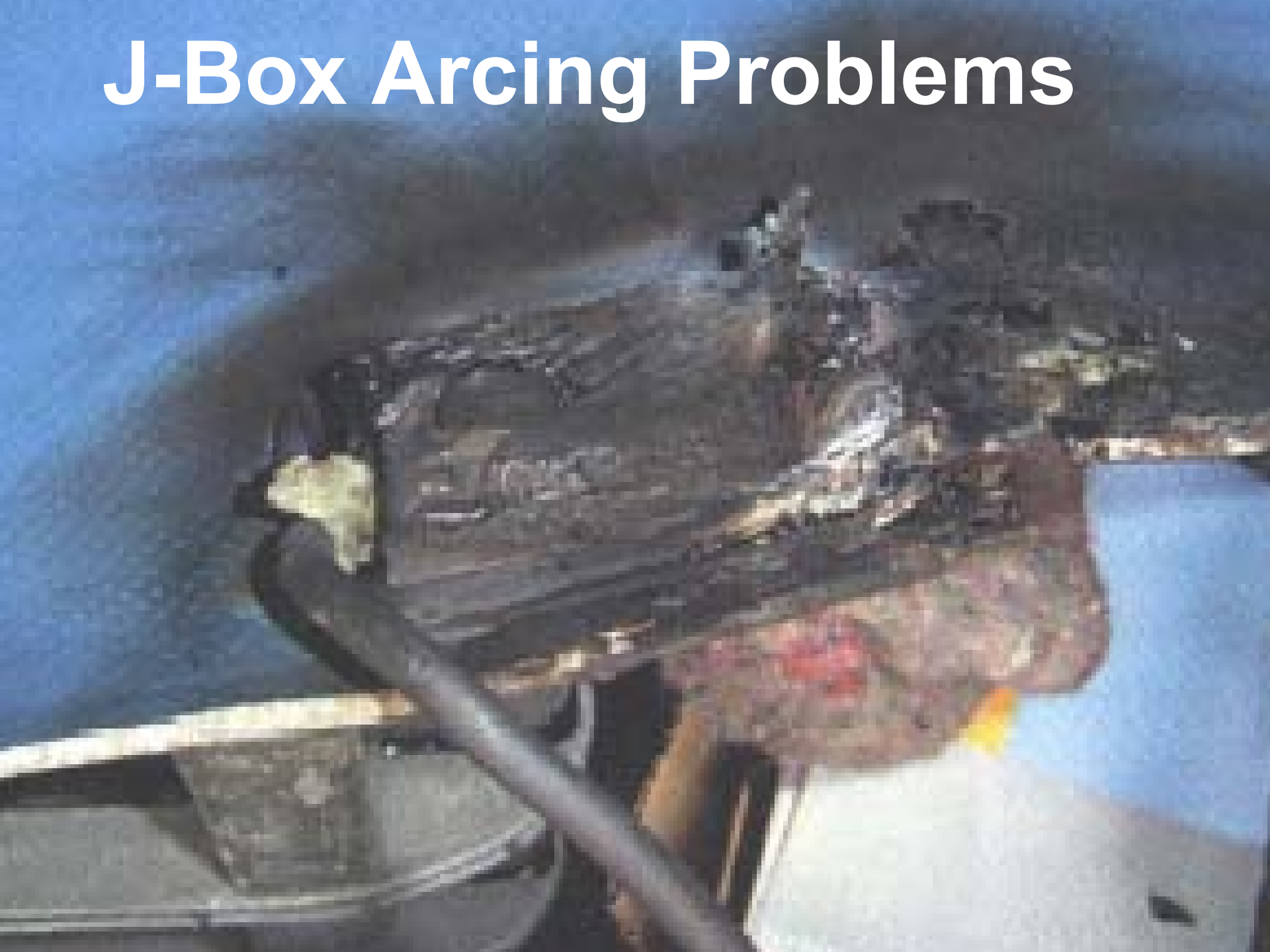

Strain from cable, birds and ice weight compounded
by sway and leverage of the cable strain relief gland.

I just need a little more cable …..

Delamination or creep can can cause these ribbons to open or short circuit


Terrible Tabbing Tether!!!

J-Box Arcing Problems



The Changing PV Landscape

- Most PV modules produced between 1990 and 2005 share similar construction, materials and manufacturing processes.
- This traditional PV module recipe was developed over years of research and testing and it has a good track record.

Past Performance is Not Necessarily Indicative of Future Results

- New players, mfrs with little or no PV experience.
- New PV module configurations and applications
- Significantly new construction techniques
- Many new construction materials
  - Thermoplastic and other new encapsulants and adhesives with low softening / melt temps
  - Conductive adhesives to replace solder
  - Polymer mounting
- New manufacturing processes

Recent Thermoplastic Concerns

- J-box – adhesion, delamination, creep or flow. Any movement can be very very bad!
- Electrical connections short or open circuits
  - Displacement of electrical conductors or components
  - Loss of contact pressure
- Mounting means delamination, creep or flow
  - Loss of mechanical integrity
  - Falling modules or falling glass

PV Polymeric Material Creep

We are seeing a transition away from crosslinked EVA based PV encapsulants toward thermoplastic encapsulants materials in the construction of PV modules.

These thermoplastic materials can flow or creep over time when exposed to the high operating temperatures.

Some of these new materials have melt temperatures less than 100C.

Existing temperature tests are normalized to 40C and chamber cycling is done at 90C max and will not always address worst case modules temperatures experienced from high ambients, high irradiance and shading conditions that can raise temperatures well above 90C.

This flow or creep of critical PV polymeric materials can result in a risk of shock, fire or mechanical hazards.

Challenge!

- **Existing evaluation programs do not address all concerns as demonstrated by increased product testing failures**
  - **New generation of PV modules,**
  - **New components and**
  - **New materials**

IEC 61730 Scope and Object

IEC 61730 describes the fundamental construction requirements for photovoltaic (PV) modules in order to **provide safe electrical and mechanical operation during their expected lifetime.** Specific topics are provided to assess the prevention of electrical shock, fire hazards, and personal injury due to mechanical and environmental stresses.

International Information Transfer

IEC PV Plastics
Project Group

IEC61730

UL61730

IEC PV Material Characterization Project Team
(TC82, WG2)

- Scope - Developing PV material property characterization requirements
  - Start with Backsheets, then Encapsulants and Front Sheets
  - 21 companies participating

- Arkema
- Atlas
- BP Solar
- Dow Chemical
- Dow Corning
- DuPont
- eTimax-Solar
- First Solar
- Fraunhofer
- Isovolta
- JEMA
- JET
- Krempel
- Madico
- NREL
- Sharp
- Solarwatt
- TUV Germany
- Tyco Electronics
- VDE
- UL

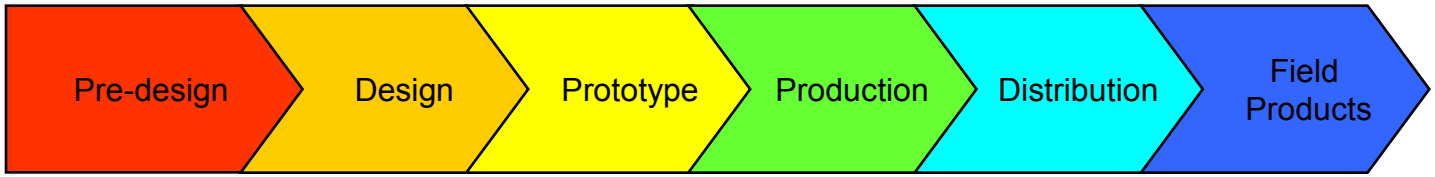
Hazard	Failure Mechanism	Test	Test Method
Electric Shock	Electric strength – dielectric breakdown due to degradation of insulating material	Dielectric Strength	IEC 60243, IEC 60216-5 (thermal aging)
	Voltage tracking – voltage causing a permanent electrically conductive carbon path after application of wet contaminants.	CTI	IEC 60112
	Material electrically conductive	Volume Resistivity	IEC 60167
	Insulation thickness consistency	Partial discharge	IEC 61730-2
	Mechanical protection from tearing	Tensile Strength, Tear Resistance, Cut Test	ISO 527-3, ASTM D1004, IEC 61730-2
	Mechanical protection from punctures due to installation tools	Puncture Properties	ASTM D7192
	Mechanical support of junction box due to movement or stretching of backsheet	Tensile Creep	ISO 899
	Superstrate / Glass movement/creep	Creep/flow test,	D6382
	Substrate / Encapsulant movement from J-box and cable weight	Dynamic Mechanical Analysis (DMA)	
	Interfacial Delamination/adhesion	Bond strength,	??
	Common failures include crazing (micro scale) that grow to cracking and mechanical failures. SEM or TEM optical microscope to view	Peel strength, Intra-layer adhesion	SAE Automotive or IEC 60950-1 (2.10.11)
	Water ingress from delamination	Water Absorption	ISO 62
Flammability	Additional fuel for the fire	Flammability test, Radiant Heat Ignitability (Cone Calorimeter test)	IEC 60695-11-10, ISO 5657
	Insulated or uninsulated wire attaining red heat during a fault causing possible ignition	HWI or Glow Wire	IEC 60695-2-20
	Loose connections and broken leads in the vicinity of the polymer material causing arcing	HAI	IEC 60695-1-1
Mechanical	Mechanical failure due to degradation of insulating material	Tensile Strength and Tensile Elongation	ISO 527-3, IEC 60216-5 (thermal aging)
	Thermal stress due to material expansion	Thermal Expansion (CTE)	ISO 11359-2
	Adhesion to glass and backsheet	Bond strength, Peel strength	?? SAE Automotive or IEC 60950-1 (2.10.11)
	Inter-layer adhesion of backsheet	Bond strength, Intra-layer adhesion	?? SAE Automotive or IEC 60950-1 (2.10.11)
	Surface treatment, chemical, corona treatment	Surface finish rating scale for machined metals?	??

Certification and Performance Certification and the Product Development Cycle

Performance Certification

One time 61215 or 61646 evaluation Follow Up Not Required

Without Follow Up modules, component and materials can change and invalidate performance certification



Safety Certification

Consulting

Preliminary Investigation

Certification

Manufacturing Follow Up Inspection & Testing

Product failure Investigation Field Reports

Harmonization of IEC 61730 & UL61730

- Goal to minimize national differences
  - IEC 61730 Amendment
- Revisions include
  - Standardized PV material characterization tests
  - Module level tests to address creep, flow, displacement and delamination failures
- International effort
  - Growing participation
  - Now is the time to get involved!

Thank You
for your attention
and future participation!

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