INVESTIGATING THE CAUSES OF FIRE
2ND INTERNATIONAL WORKSHOP
TUESDAY, 7 MAY 2013 · 8.30-18.00
ISTITUTO SUPERIORE ANTINCENDI · Via del Commercio, 13 · 00154 Roma

Fire Ignition Analysis on Photovoltaic Roof and Related Buildings

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D.C.P.S.T. Active Fire Protection Area

A new Fire Scenario...

- A number of fires occurred in the weeks following the installation completion
- Sometimes before the first commissioning and the external electrical network connection
- Faulty Modules, Poor Design, Electrical Connections errors, Shading could be responsible for the fire

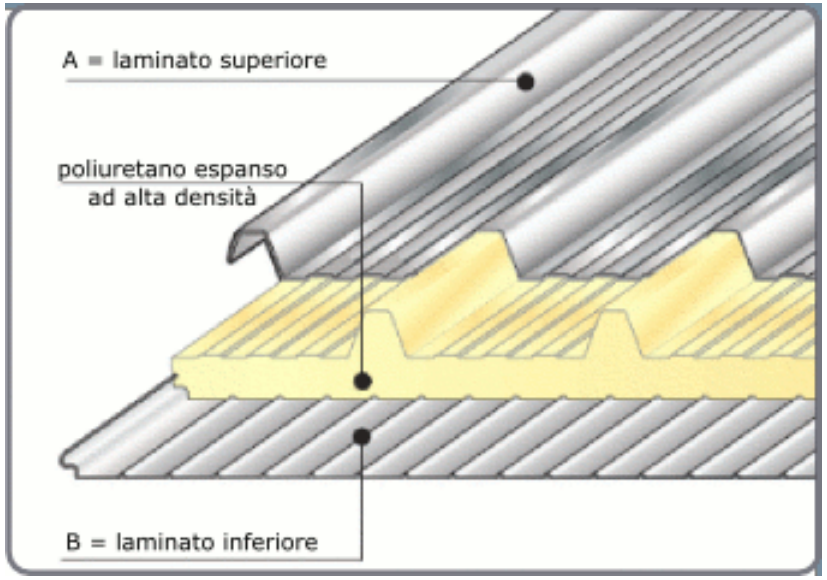
A new Fire Scenario...

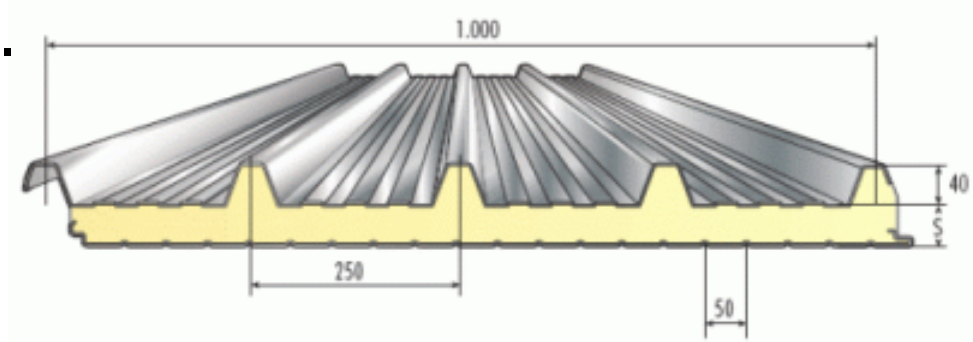
The photovoltaic plant components (on a roof or on a building façade) could:

- modify the propagation of fire outside or through the building;
- interfere with the smoke and venting systems of the combustion products;
- obstacle the fire extinction operations
- introduce a further hazard through electrical shock for firefighters and rescue operators for the presence of circuit energized components.

- Combustible insulating foam ignition
- An initial smoldering combustion
- Pyrolysis rate increases as air leaks inside the PU sandwich Panel
- The cover and the plant resulting totally destroyed
- smoke leaking inside the compartment
- Ignition of a lower fire compartment

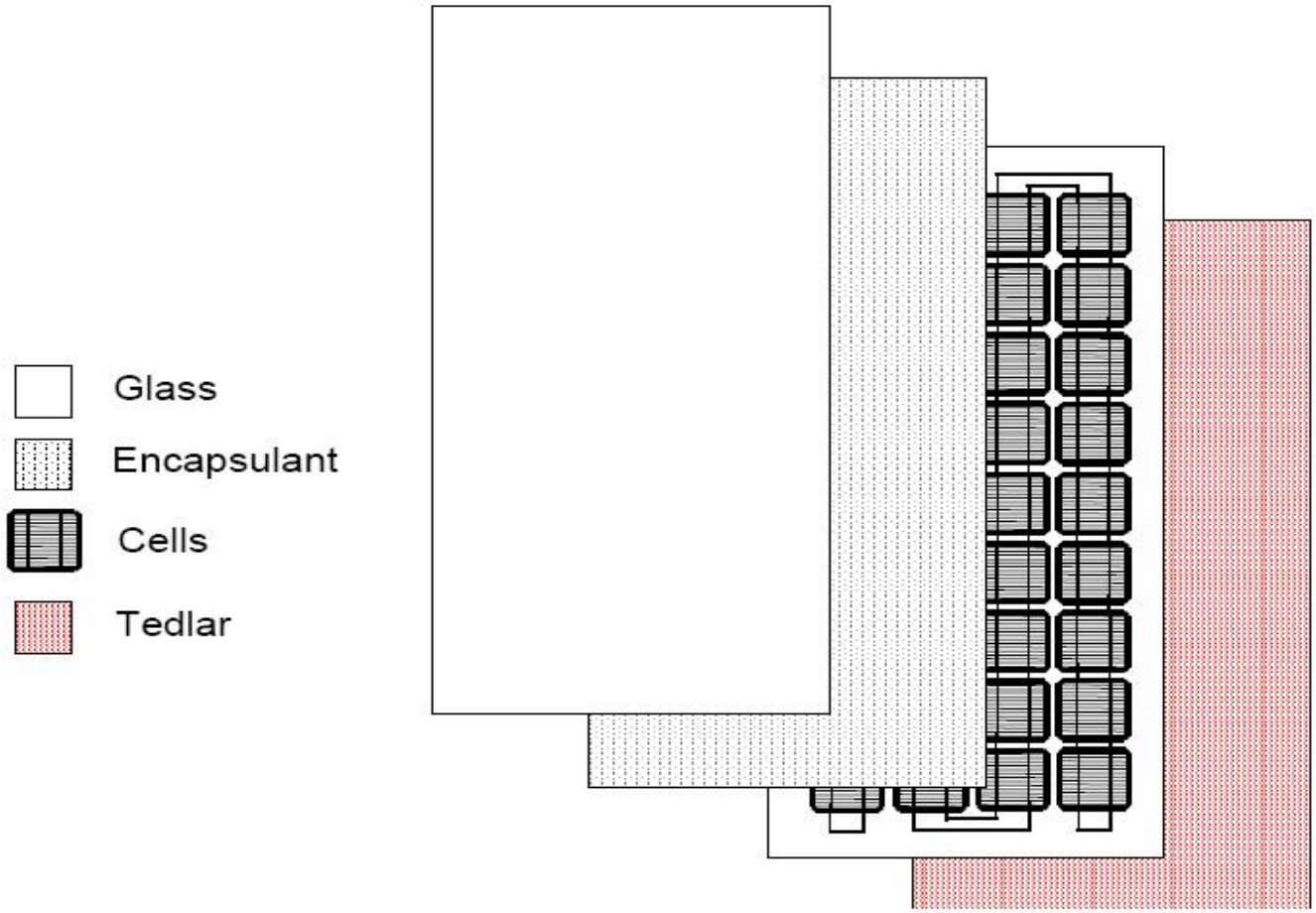
•Polyurethane (PU) core material is considered to be the best material in keeping warm and thermal insulation, but is easily ignitable, and if a fire starts from a PV module or an electric board, it easily spreads out on the roof – also favored by the wind action – through the PU core of the cover sandwich panels.





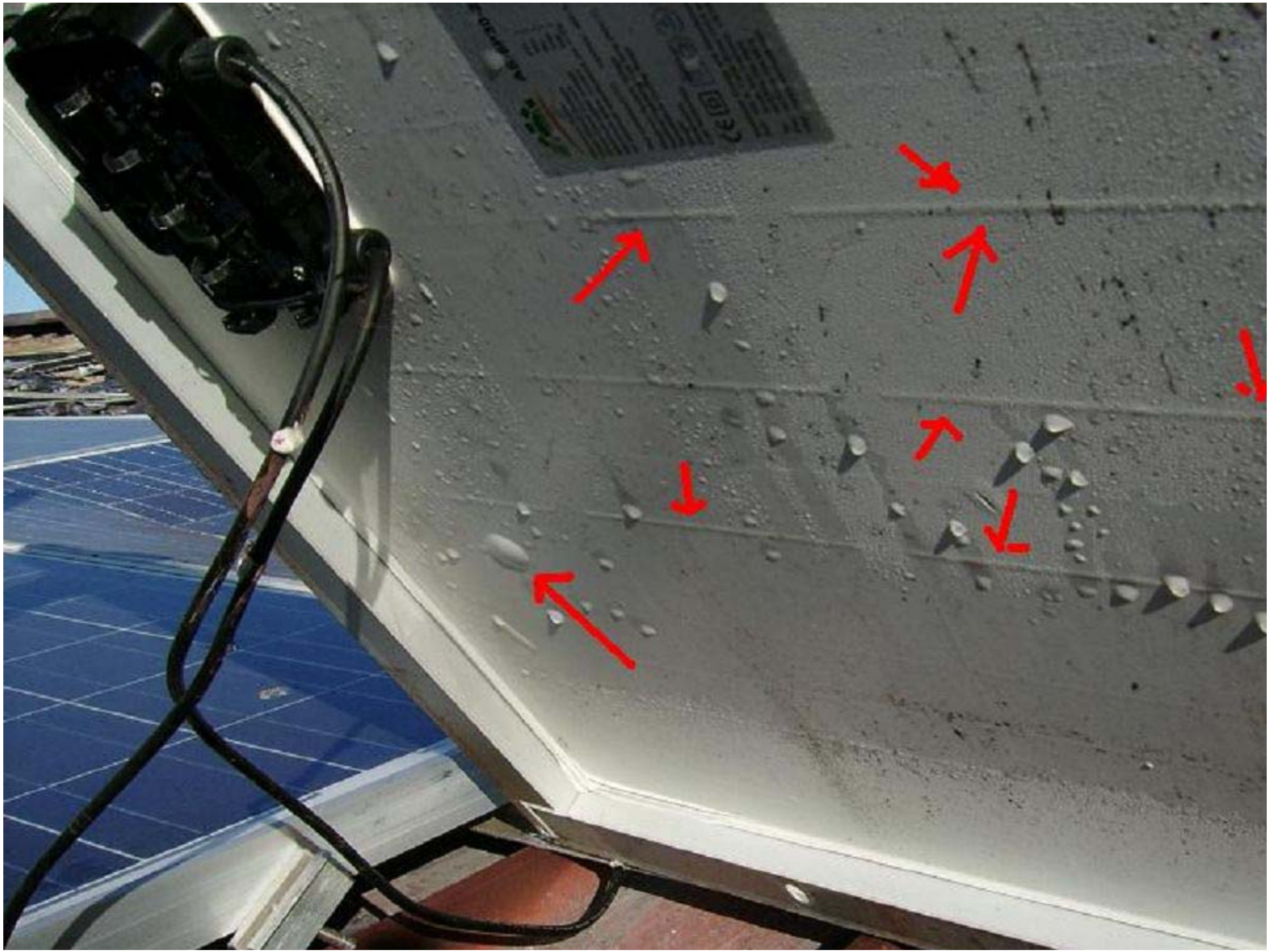
The PV module structure

(mono & poly cristalline)

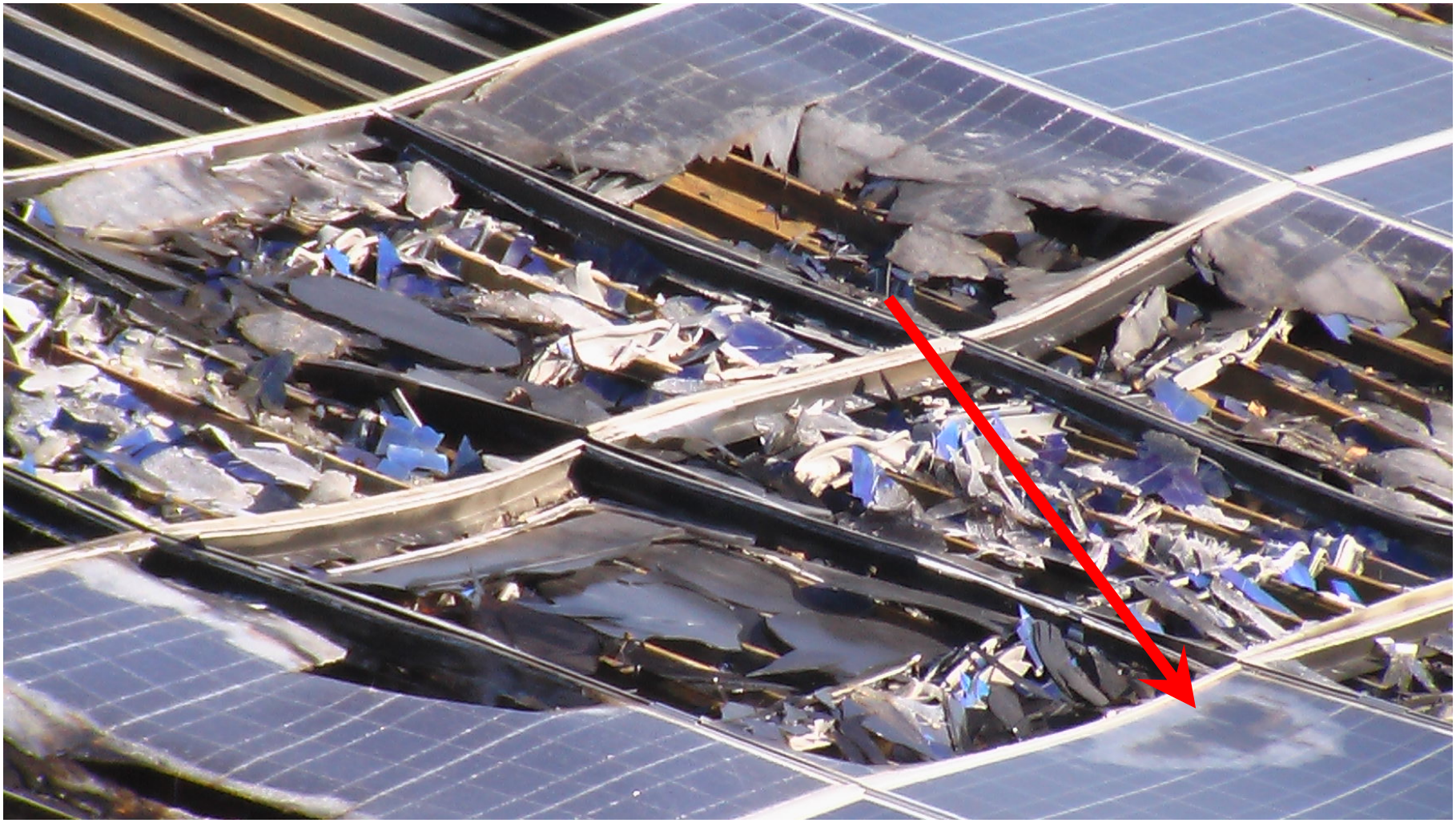


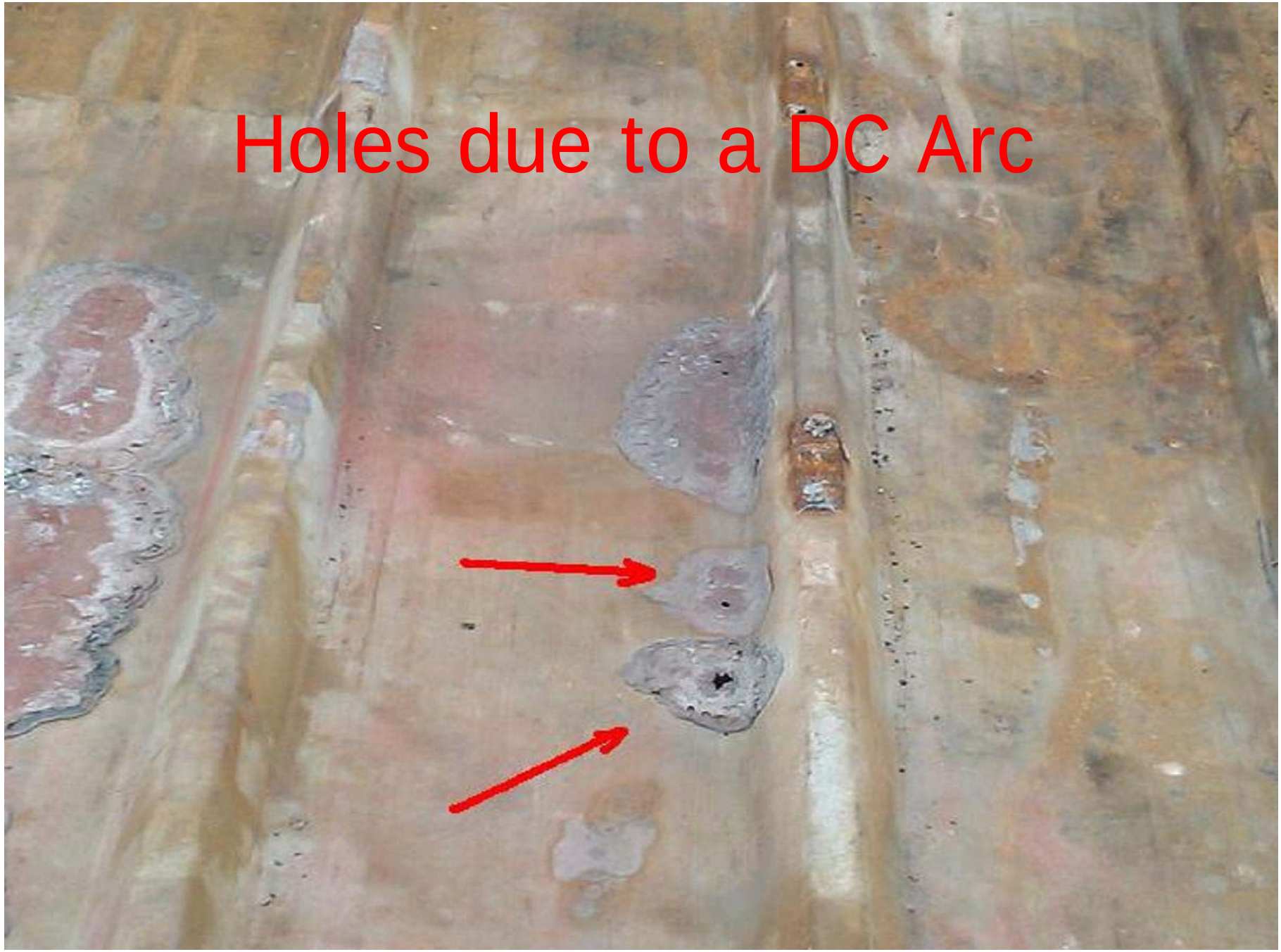
Fire Investigation after two major Fire events

- Resistive (Joule) heat release evidence on PV modules
- Mismatch evidence on single cells
- DC Arcing and holes on the sandich upper stell surface
- Reverse currents
- bypass and string dyodes
- HOT SPOT



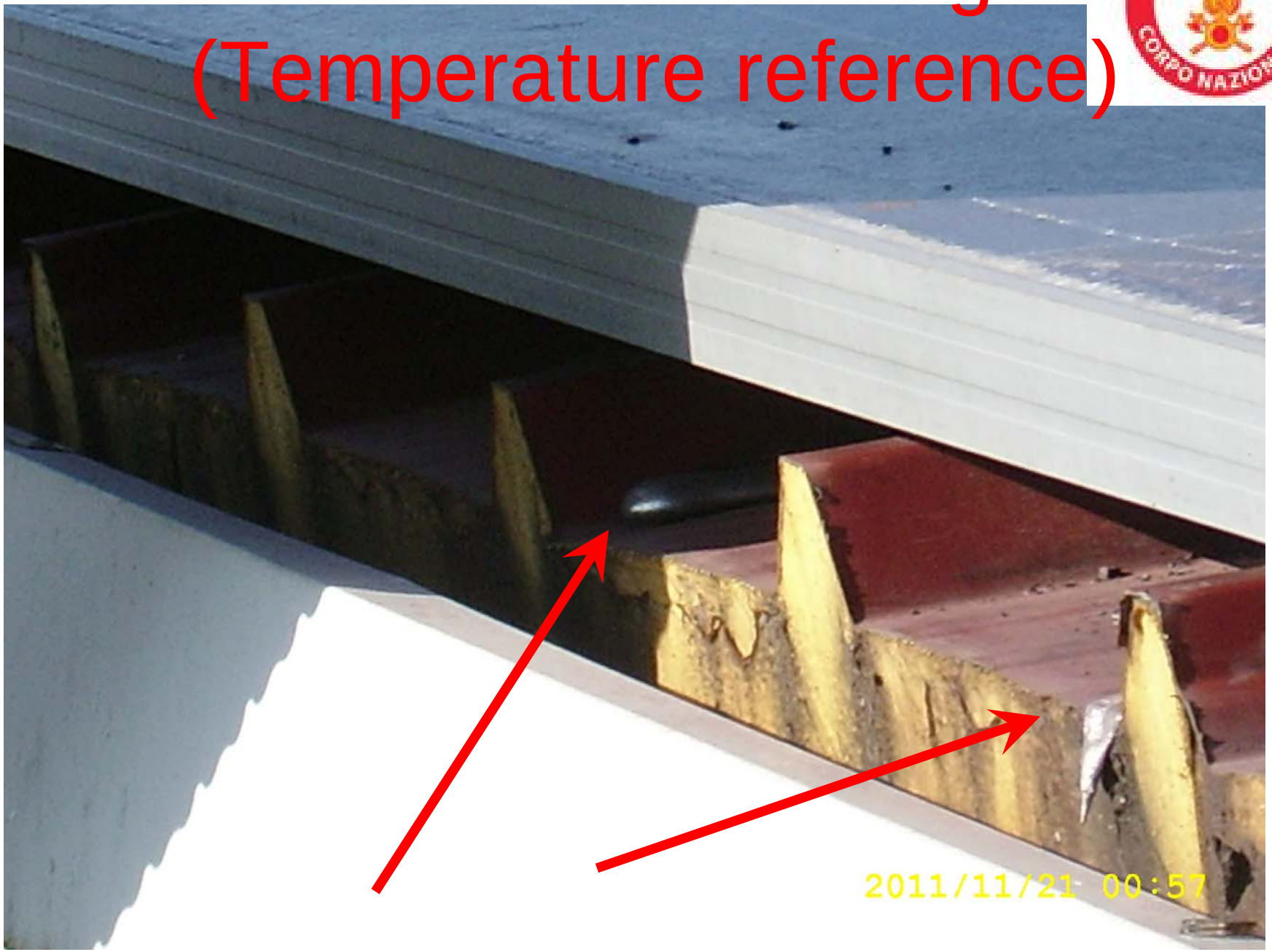

VIGILI DEL FUOCO
CORPO NAZIONALE
2011/11/20 22:04




Holes due to a DC Arc

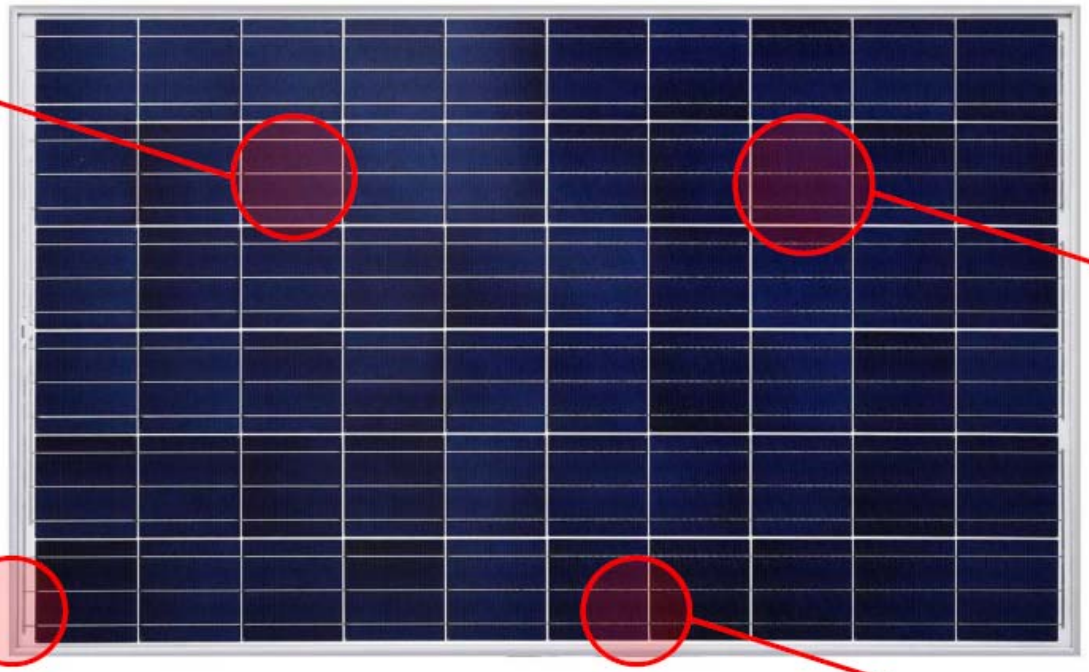
PU pyrolysis

Aluminum Melting (Temperature reference)



Cables Crushing

PV MODULE HOT SPOT MECHANISMS



•Ribbon to Cells Connections

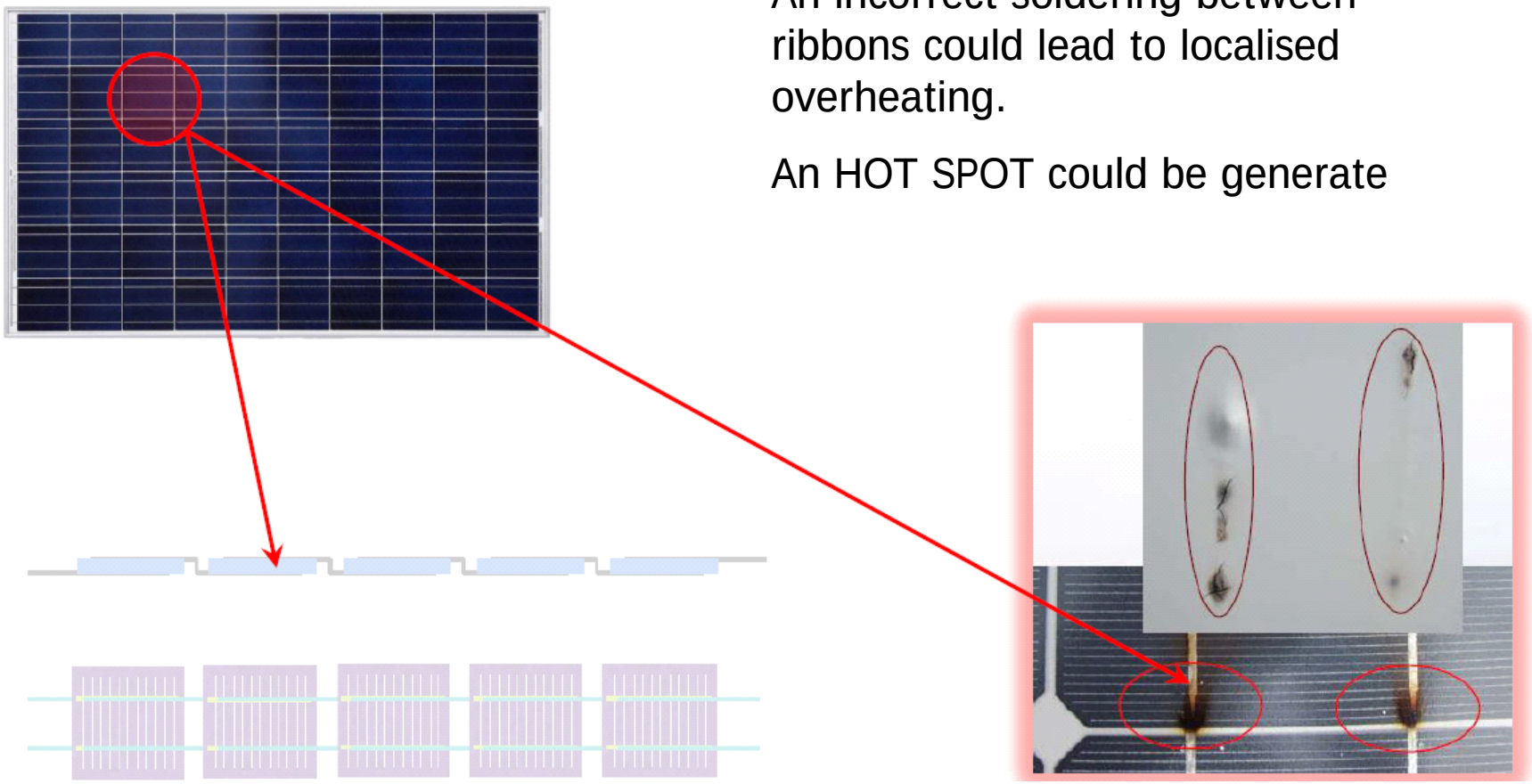
Cell

•Collector Ribbon to Busbar Connections

Tabbing to Bassing Connections

Ribbon failure connections between cells due to mechanical flections

Ribbon to cell Interconnections Failure [1]

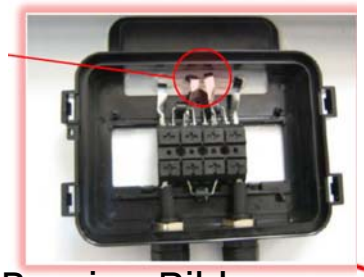


An incorrect soldering between ribbons could lead to localised overheating.

An HOT SPOT could be generate

[1] SOLAR MODULE ARC FAULT MODELING ATSANDIA NATIONAL LABORATORIES Jason Strauch, Michael Quintana, Jennifer Granata, Ward Bower, Scott Kuszmaul Sandia National Laboratories*

Junction Box Fire Ignition Mechanisms



•Bussing Ribbons Placements

•By-Pass Diode

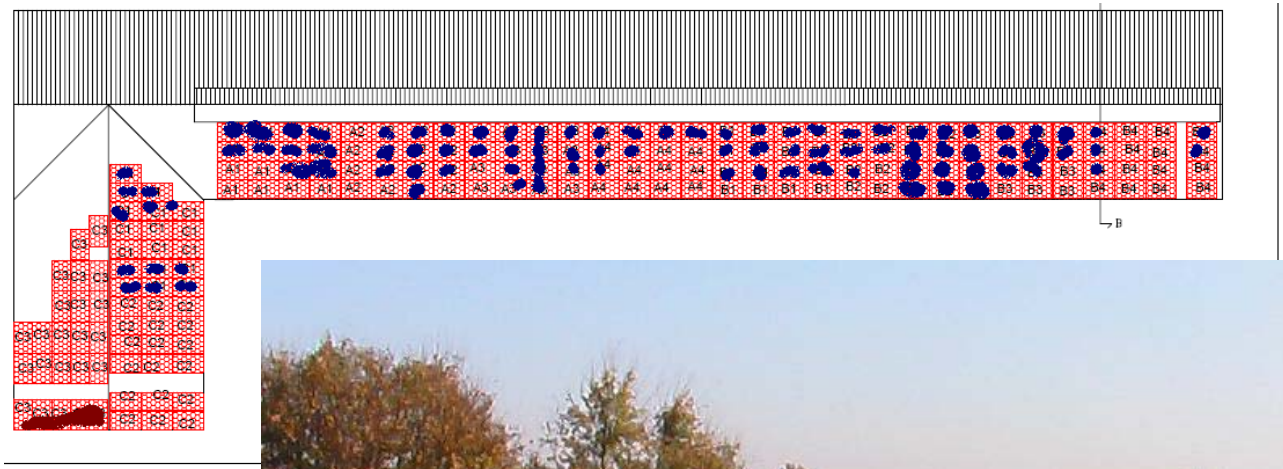
•Bussing ribbon to JB connections

•JB tp Cable connections

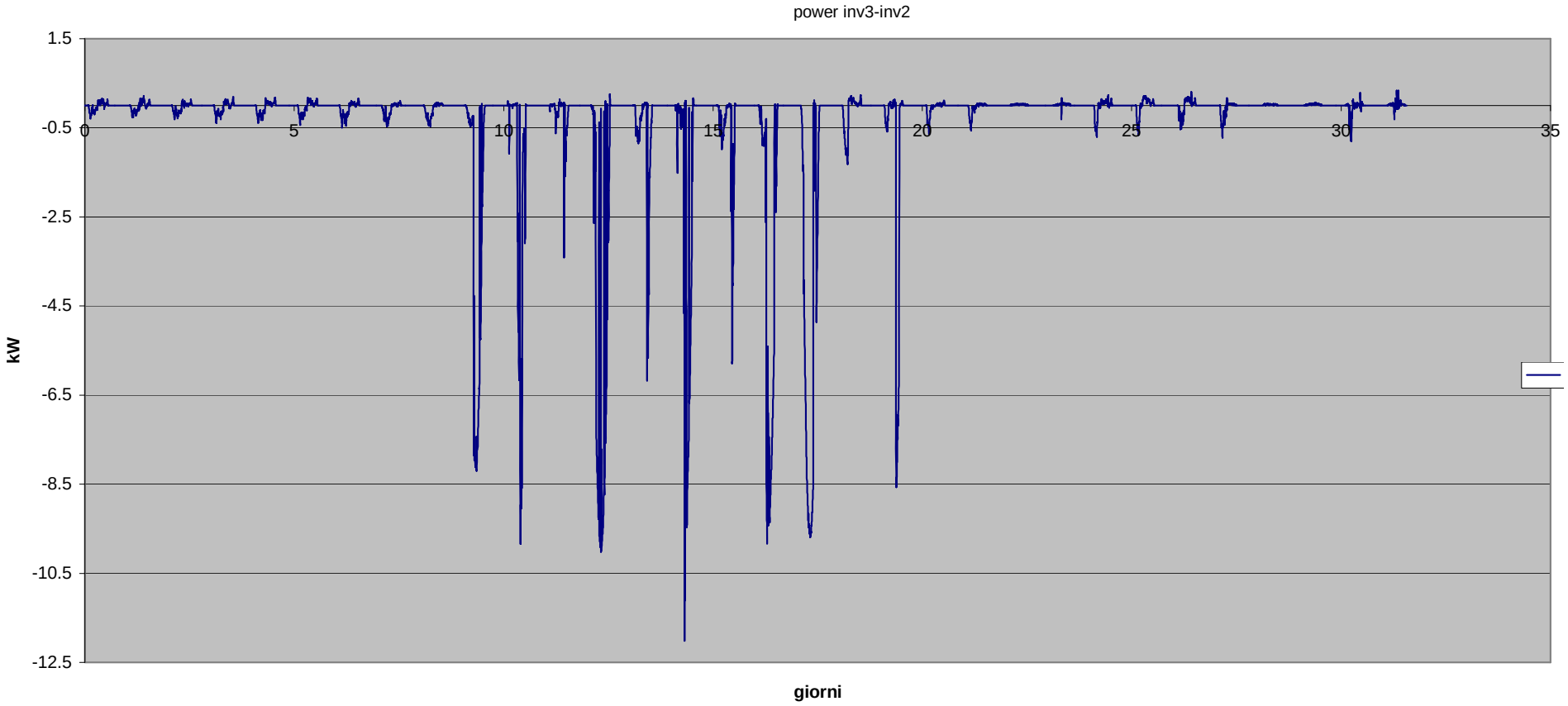
•Cable plug connectors

IF JB placements is poor, lack in distances between positive and negative voltage could lead to a parallel DC ARC

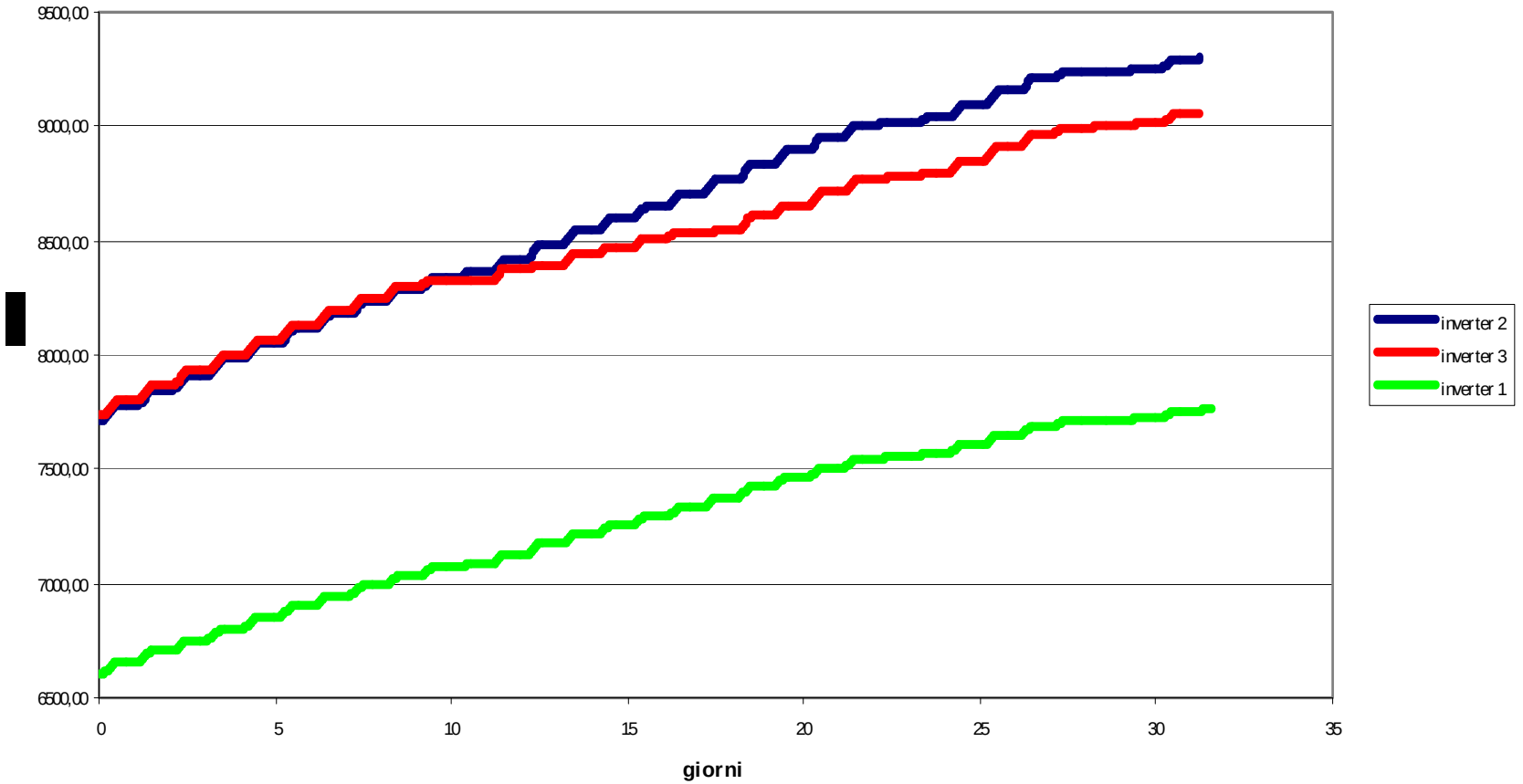
Post incident inverter data analysis
Twin arrays power comparison



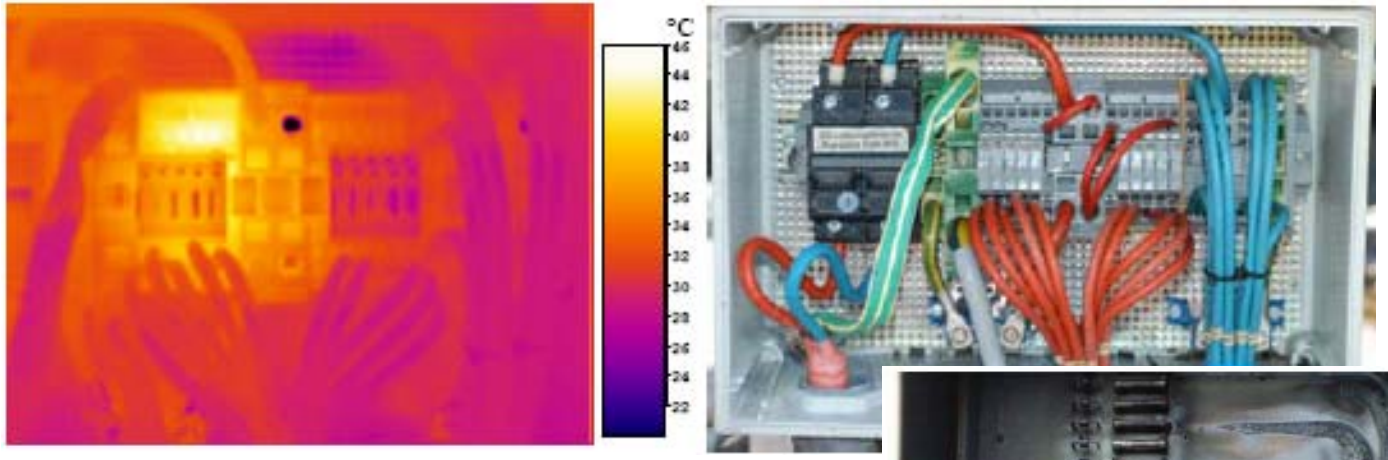
Post incident inverter data analysis
Twin arrays power comparison

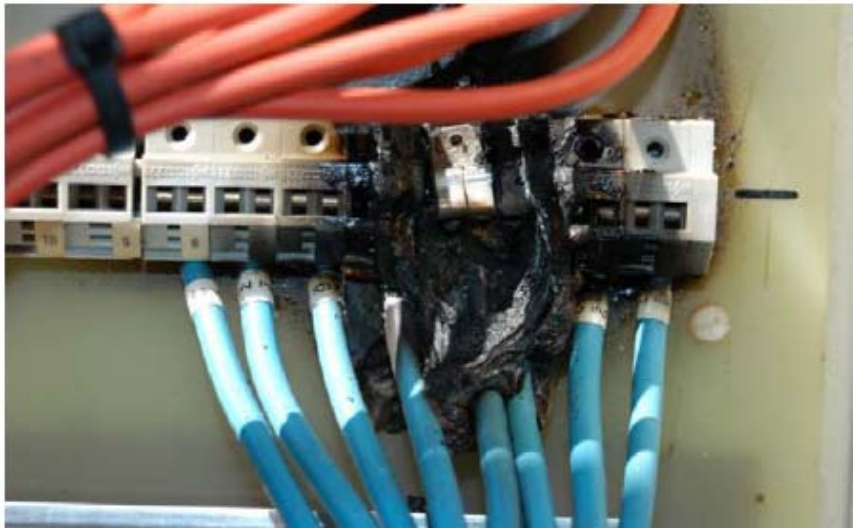


Post incident inverter data analysis

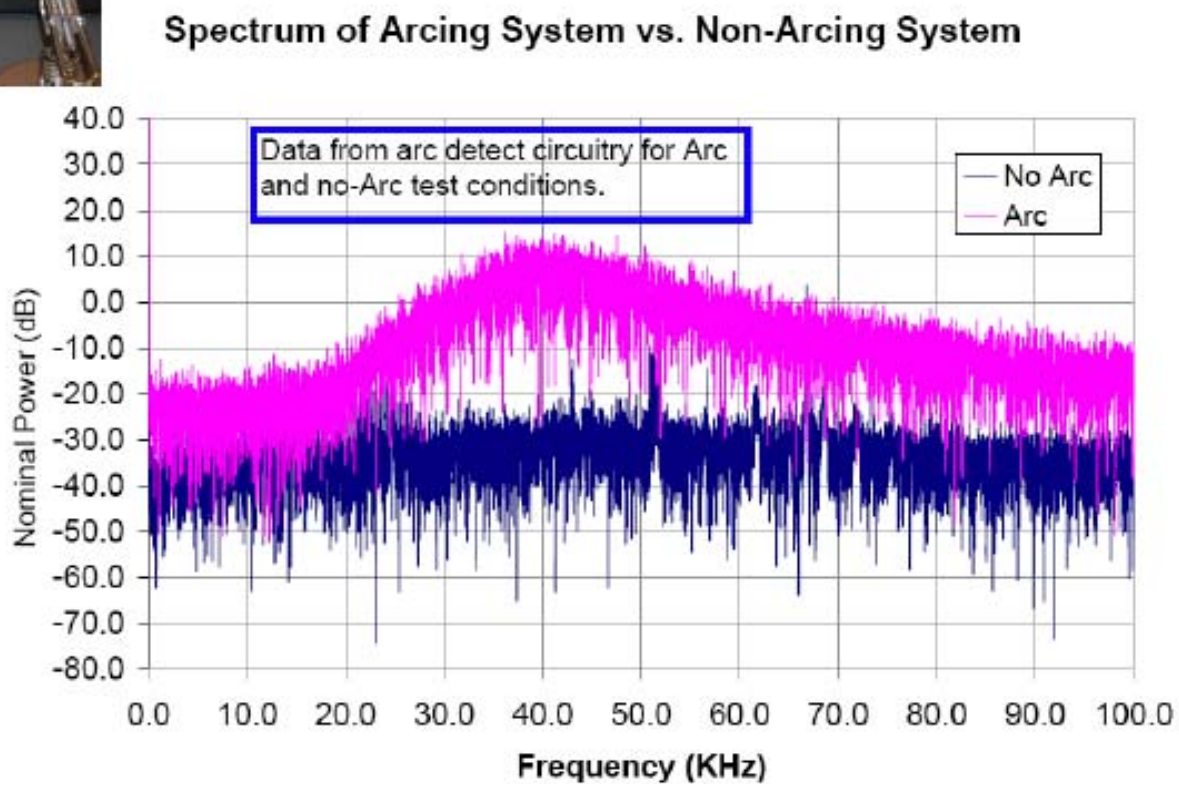


Early fault detection : IR Thermograph





Early fault detection : AFCI Arc Fault Circuit Interrupter [2]



[2] Sandia labs and UL PV AFCI detection research

Conclusions

•There are a number of evidences and indications in order to asses the ignition of a cover due to a PV plant;

•The analysis of monitoring inverter data, like power and cumulative energy produced by PV arrays, could be an useful tool for an early PV fault detections (ground fault, strings mismatch, modules improper shading, energy dissipations ...);

•However in order to keep not only efficient but also safe, a PV plant must be properly maintenanced and verified;

•Interactions between PV plants and combustible insulating cover roofs represents a fire ingnition and spreading main concern for buildings.

Any Questions?

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piergiacomo.cancelliere@vigilfuoco.it