



# EPC Perspective

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McCarthy Building Co.



RENEWABLE ENERGY

**MCCARTHY**



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Manager, McCarthy  
Building Co.*

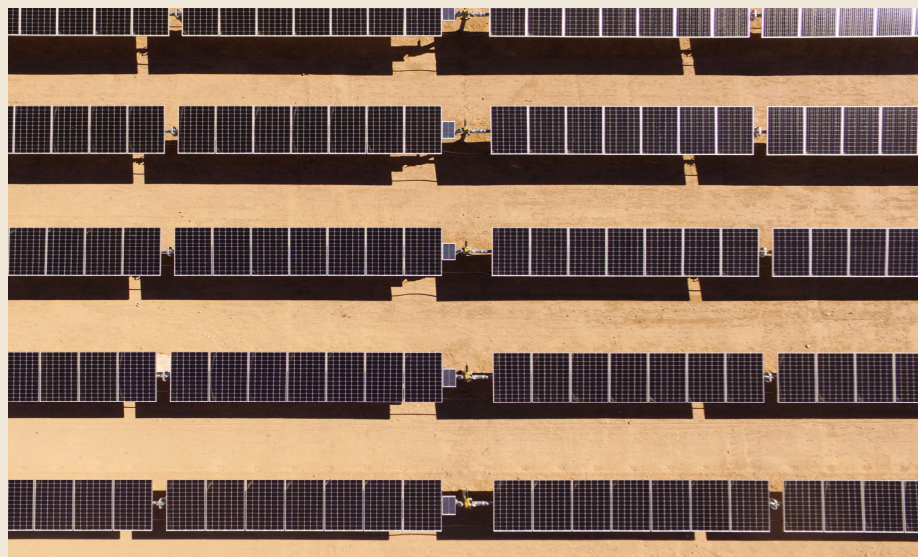


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# Overview

- Field Findings
- EPC Enhancements
- Mitigation Efforts





# Top 5 Warranty and Quality Topics '23

1. Medium Voltage Cable/Electrical Utilities
2. Electrical Harness/PV Connector Failures
3. Material Storage/Shakeout
4. Rodents
5. Civil Erosion



Evidence of improper tooling used for torquing



Pliers/ Channel Locks marks



Open connector, not fully engaged.



Visible debris or foreign particle inside connector body







# RENEWABLE ENERGY QUALITY FLASH



Date:

Amended 8/16/23

Project/ Department:

RE Electrical Department- Contact: Kyle Phelps [PhelpsKOPhelps@mccarthy.com](mailto:PhelpsKOPhelps@mccarthy.com)

Product Information:

Mc4 and TE2 type connectors

## WHAT YOU NEED TO KNOW/ SUMMARY:

### PV Connector Quality Flash

Recently our projects have seen an uptick in PV connector failures. These failures are currently under investigation. Please review the recommendations below. There are five follow up action items below for all project teams to review to potentially mitigate.

#### PROCESS INFORMATION:

#### PV Wire Management

#### KEY FINDINGS:

Connector failures may be caused by inadequate air flow, overheating, UV degradation, or faulty connections. Please review the following action items.

#### RECOMMENDATIONS/ FOLLOW UP:

- Bundling connectors together may contribute to inadequate air flow and overheating. The recommendation is to avoid bundling more than 3 connectors together. (see figure 3)
- Locating connectors inside split-loom or any other conduit may contribute to inadequate air flow and overheating. The recommendation is to avoid locating connectors inside split-loom. (see figure 4)
- UV light can degrade the connector and increase the temperature. The recommendation is to locate all connectors behind the panel and out of direct UV exposure. See correct connector location circled in green in figure 1.
- Field made connections can expose the cabling to environmental conditions and affect the connections integrity. Please be advised that field made connections are the exception rather than the rule. Field made connectors are currently allowed only as a last resort. (see figure 2)
- Perform an assessment of these conditions in work completed and future work, including potential mitigation measures to review with project and quality leadership.

## PHOTOS/ DRAWINGS:



Figure 1

Figure 2



Figure 3

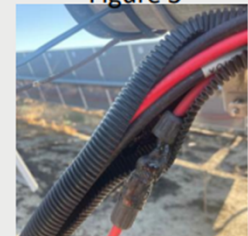


Figure 4



# How Can An EPC Enhance Connector Reliability?

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- Innovative Technology
- Early Identification



# McCarthy | OnSight

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How is McCarthy using OnSight technology?

## Pre-energization inspections

- Module cracking inspections
- Wire management inspections
- Module bar code scanning.
- SWPP Inspections

## Post-energization inspections

- Connector health monitoring
- Module performance and temperature reading
- O&M remediation
- Vegetation monitoring
- SWPP Inspections
- Gauge readings
- Substation thermal monitoring
- Wildfire monitoring

## Current status of development

- GIS
- Reporting – Data workflow, PROCORE & GIS Data Integration



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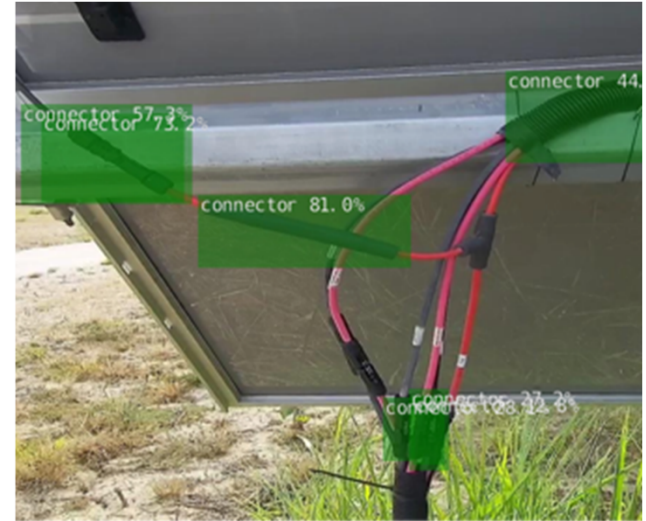
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# OnSight Findings

McCarthy's RE Quality Group is leveraging OnSight Technology's robots and machine learning to identify leading indicators of connector health and quality.

- Preventive plant maintenance
- OnSight works within McCarthy's existing quality processes, providing a differentiated quality product.



# Mitigation Efforts

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- Craft Training
- Design
- Best Practices



# Mitigation Efforts

- Craft-focused manufacturer training. McCarthy's craft workforce is engaging with connector manufacturers to ensure qualified personnel are accomplishing connector repairs.
  - McCarthy has had approximately 90+ personnel trained and certified by Staubli.
- Design-focused – Efforts are made through procurement to ensure no intermating of connectors.
- Verification of ULs on integrated wire harness solutions through 3<sup>rd</sup> party testing proves to be a “worthwhile” cost to EPCs.

## NEC COMPLIANCE RISK



- Article 690.33(C) of the 2020 NEC states “Where mating connectors are not of identical type and brand, they shall be listed and identified for intermatability, as described in the manufacturer’s instructions”
- Product listing as identified in this NEC article is difficult to obtain as it requires long-term cooperation and sharing of intellectual property between competing product manufactures. Because of this, no PV connectors of different brands are currently listed to be used together and it is likely they never will be.
- In other words, it is impossible to comply to the letter of NEC 690.33(C) when using connectors from different manufacturers.

## THE PATH FORWARD

### IF POSSIBLE, ENSURE ALL PROJECT PV CONNECTORS ARE OF SAME MAKE AND MODEL

- Make best efforts during design and procurement phase to ensure that all PV connectors which will mated together are of the same make and model.
  - This resolves all issues related to PV connector intermatability
  - Particular attention should be paid to interface of PV strings with wiring harnesses







## ⚡ Solar PV Connector Safety

 Connector issues can cause fires / worker injuries	 Proper installation is important. Unskilled or untrained workers installing PV can lead to issues	 Connectors provide connections between the array	<ul style="list-style-type: none"> <li>• No universal standard for PV connector design</li> <li>• Connectors with high operating temperatures may be the only warning sign of failure</li> </ul>
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### Recommended Installation Practices

 Same manufacturer or manufacturer provided tools	 Proper tools must be used according to manufacturer instructions	 Follow connector manufacturer instructions	 Use only connector parts of the same manufacturer. Interoperability issues may exist when using connectors from different manufacturers
 2020 NEC/UL6703 requires that two parts of connector pairs must be tested together and certified for intermatability (items must be listed, and to be listed, they have to be able to work together)	 Ensure materials are clean before installation. If damaged, soiled, or exposed to water before installation, there is no way to clean		

### Warning Signs

 Loose or disconnected connectors or screw nuts	 High temperatures. Melted, discolored, or cracked casing	 High resistance due to soiling, corrosion, or foreign particles or improper surface contact on metal contacts	 Increased alarms on monitoring systems (ground, isolation, loss of energy yield, and/or arc faults)
 Moisture or water ingress - broken seal and / or separated connectors	 Material degradation and exposure to elements	<b>Why failures happen</b> <ul style="list-style-type: none"> <li>• Improper installation</li> <li>• Lack of training</li> <li>• Faulty materials</li> <li>• Improper installation tools</li> <li>• Mismatched connectors</li> <li>• Counterfeit connectors</li> </ul>	

### Diagnosing and Preventing Connector Failure

 High temperature because of increased resistance	 Use thermal imaging to find abnormal temperature readings. Connectors operating at over 85°C may be failing	 Use thermal imaging to find connectors that are hotter than others	 Thermal imaging on group can identify issues, drone imaging may miss connector issues that are underneath modules
 Visually inspect connectors to locate any physical or heat related damage	 Issues with connectors can cause power loss, fires, or create ground faults that could be lethal		 Issues impact performance, cause downtime, and have commercial / monetary impacts

Please share this free resource to save lives



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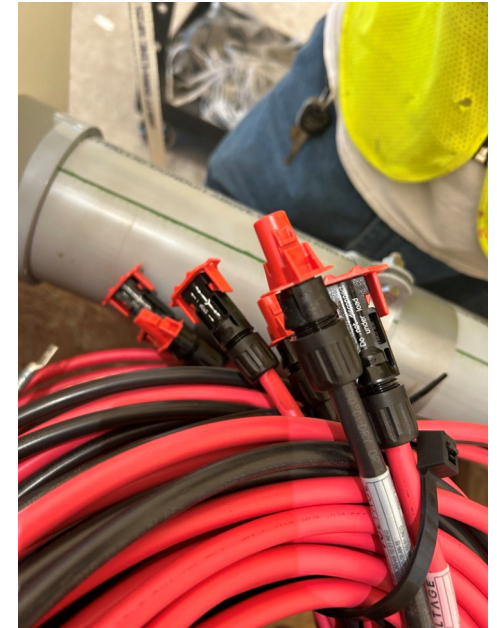


# Mitigating Risk

- Concerted efforts to cap all end-of-row connectors.



As Received



- Module manufacturer education.
  - Module manufacturers are providing modules with no connector caps. This further increases connector challenges in the field.



# Summary

- The renewable energy industry lacks guidance around PV connectors.
  - UV exposure, connector temperatures, and UL Standards.
  - Design Build Contractors will continue to struggle to achieve plant life expectancy of 25+ years.
- McCarthy and other EPCs should continually be focused on identifying leading indicators of poor quality and early diagnosis of faulty connectors to prevent plant degradation.
- Risk Mitigation is possible and effective. EPCs need to have plans in place to ensure connector reliability.





THANK YOU