2023-2025 WMP
Joint IOU Covered Conductor Working Group

Testing Workshop #2

August 7, 2023

Background

- SCE, PG&E, and SDG&E collaborated on evaluation of covered conductors for effectiveness in reducing wildfire risk
  - Pacificorp, BVES, and Liberty later joined this effort
- Evaluation was broken down into two phases:
  - Phase 1 objectives: Develop IOU consencus Failure modes and effects analysis (FMEA) and document prior research and testing on covered conductor failure modes and effects on wildfire risk
    - Phase 1 was concluded in December 2021
  - Phase 2 objectives: Perform joint IOU testing on gap areas identified in phase 1 report to characterize the impact of covered conductor on various failure modes
    - SCE, PG&E, and SDG&E joint commissioning of KINECTRICS and Exponent
    - PG&E performed additional complimentary testing
    - SDG&E performed additional simulations and testing
- Joint IOU collaborative efforts results inform wildfire risk reduction calculations, PSPS thresholds, and maintenance & inspection updates

Phase 1 Report Summary & Phase 2 Scoping

Phase 1 Recommendations	Relevant Phase 2 Testing
Characterize CC susceptibility to certain mechanical failure modes (Aeolian vibration, galloping, etc.)	Tensile testing
Characterize key understudied contact-mediated fault scenarios (e.g., foreign object contact)	Arc testing, ignition testing
Characterize CC-specific failure modes	Moisture ingress testing, flammability testing, corrosion testing, tensile testing

- Exponent previously conducted a literature review for the California IOUs on the effectiveness of covered conductors (CCs) for wildfire mitigation ("Phase I"). This work identified selected areas for further study.
- The current scope is comprised of physical testing to address areas identified by the previously conducted literature study. These include:
  - Phase-to-phase contact testing: to understand the ability of CCs to prevent phase-to-phase arcing when in contact with foreign objects.
  - Simulated wire-down testing: to understand the ability of CCs to prevent ignition of dry fuel in the event of a wire-down event.
  - Fire risk: to understand the propensity for the polyethylene covering to ignite in the event of a nearby fire.
  - Corrosion susceptibility: to understand the corrosion susceptibility of CCs near stripped ends relative to bare conductors.
  - System strength: to understand the mechanical limits of CC systems.

Joint IOU Phase 2 Testing Scope and Overview

- Testing performed at KINETRICS[1], a nationally recognized independent laboratory and testing facilities (selected from 37 options)
- Testing matrix reviewed by:
  - Engineering and ERM
  - PG&E and SDG&E
  - Filsinger
  - Independently facilitated and reviewed by Exponent[2], KINECTRICS
- Collaboratively developed a systematic testing program to investigate different aspects of covered conductor effectiveness. Six different groups of tests with various scenarios at both 17 kV and 35 kV

Test Group	Examples
Arc Testing	Arc testing of various contact from objects scenarios (i.e., branches, palm frond, mylar balloon, animal and conductor to conductor); some conductor flaws will be introduced Ignition testing of broken covered conductor in brush
Ignition Testing	Ignition testing of broken covered conductor in brush
Mechanical strength testing of the system	Tensile testing of conductor (with and without) splice and hardware attached (critical for PSPS input)
Electrical breakdown strength testing	Insulation breakdown strength, leakage current
Flammability testing	Ignition heat flux
Water ingress and corrosion testing	Dye ingress and salt spray

Testing Input

Peer IOUs

PG&E

SDGE A Sempra Energy utility

Consultants

Ex

FILSINGER ENERGY PARTNERS

Labs

KINECTRICS

PG&E Testing Scope and Overview

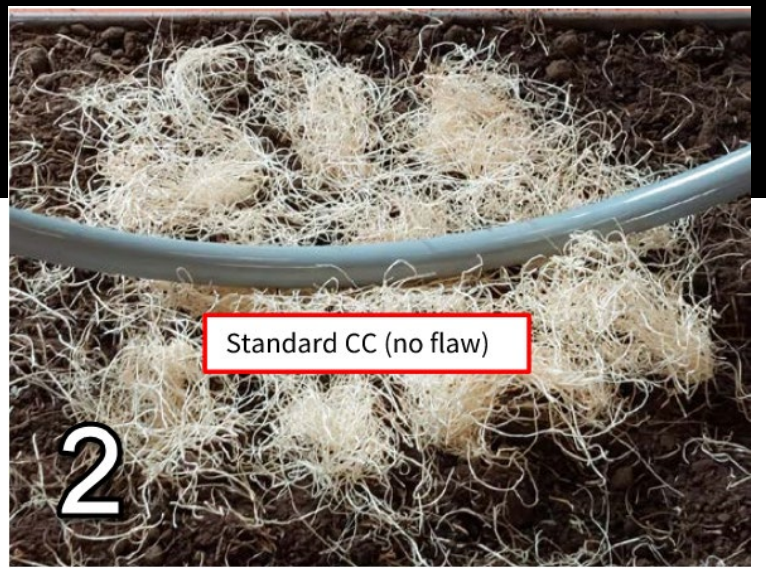
- The purpose of this testing is to provide insight into the effectiveness of XLPE-covered conductor(s) for overhead distribution system hardening. Specifically, to address the following:
  - Qualitatively evaluate proposed covered conductor(s) against the bare conductor
  - Identify the presence of active degradation mechanisms pertaining to covered conductors.
  - Document the material, electrical, mechanical, and environmental properties.
- Majority of tests conducted per ANSI/ICEA S-121-733 unless otherwise specified. Some properties of interest not defined or required by ANSI/ICEA S-121-733 were determined by alternative methods.

Test Scope	Description
Material Characterization	Filler content, water absorption, DSC, FTIR, thickness measurements
Enhanced Electrical Testing	Leakage current testing, abraded insulation leakage current
Flammability Testing	Self ignition and propagation
Moisture Testing	Water ingress testing
Mechanical Testing	Mechanical pull-out and slippage testing
Corrosion Testing	Environmental salt and accelerated aging
Excess Heating	Shrink back retraction under heat
UV Exposure	Weathering testing and material characterization
Tracking Testing	Tracking resistance testing
Lightning Testing	Resistance to lightning and destructive testing at large current/voltage

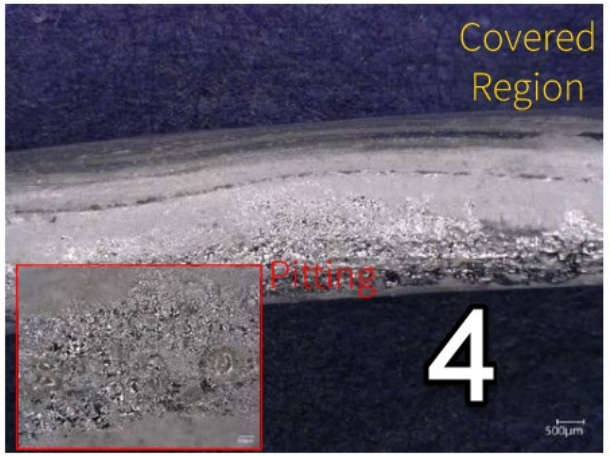
SDG&E Additional Testing

Completed Testing

1. Phase-to-phase contact
2. Simulated wire-down events
3. Flammability
4. Corrosion susceptibility
5. System strength



Strands under covering near stripped end after salt spray testing



SDG&E Exponent Study

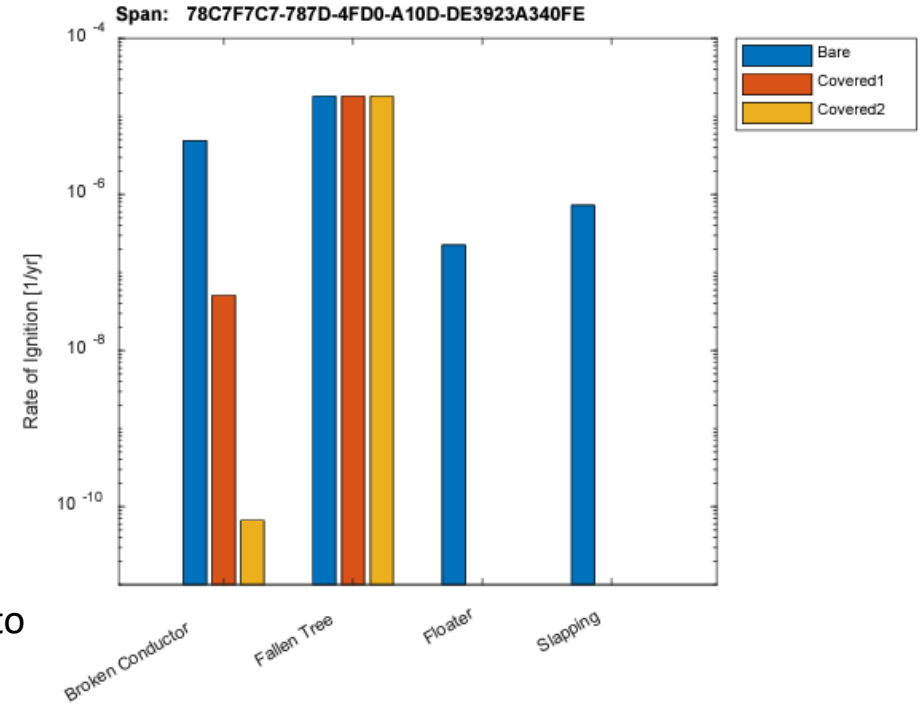
Ignition rates studied for bare vs covered conductor across:

- Broken Conductor
- Fallen Tree
- Debris phase-phase bridging
- Slapping

Ignition rates utilized site-specific conditions and meteorological data.

Observations

- Covered conductor less susceptible to ignition events than bare conductors.
  - Debris bridging and wire slapping significantly less likely to lead to arcing.
  - Tree fall-in is uncommon, however ignition rate is the same for bare and covered conductors in this scenario.
  - Covered conductor requires significant aging for the cover material to degrade enough such that slapping or debris bridging can lead to arcing. This is unlikely to occur within the first twenty years.

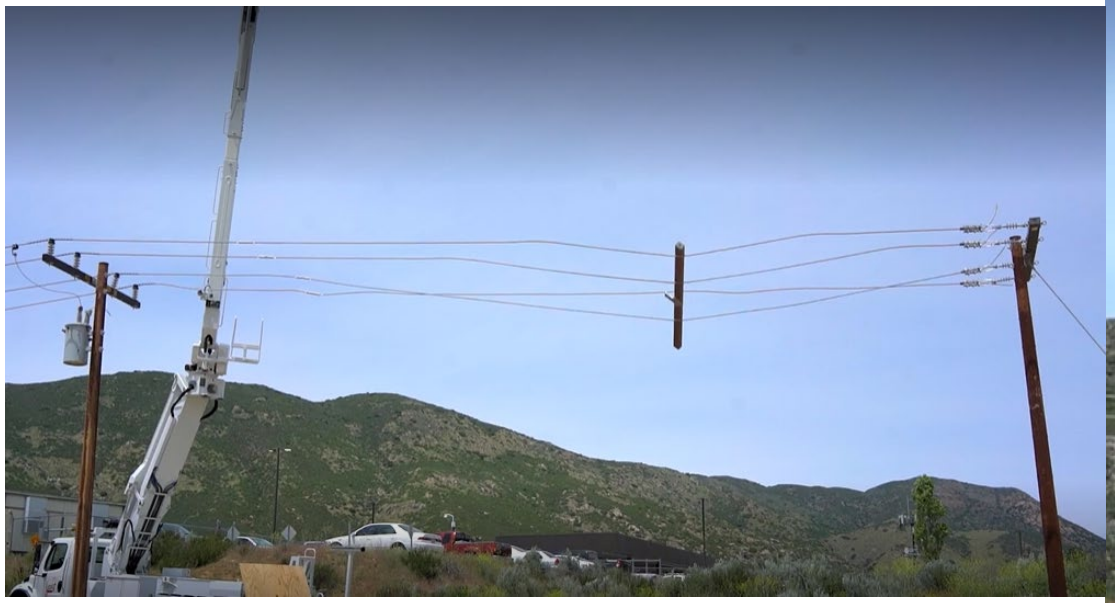


SDG&E Destructive Testing

Flying object testing

Covered Conductor Safety

Falling object testing



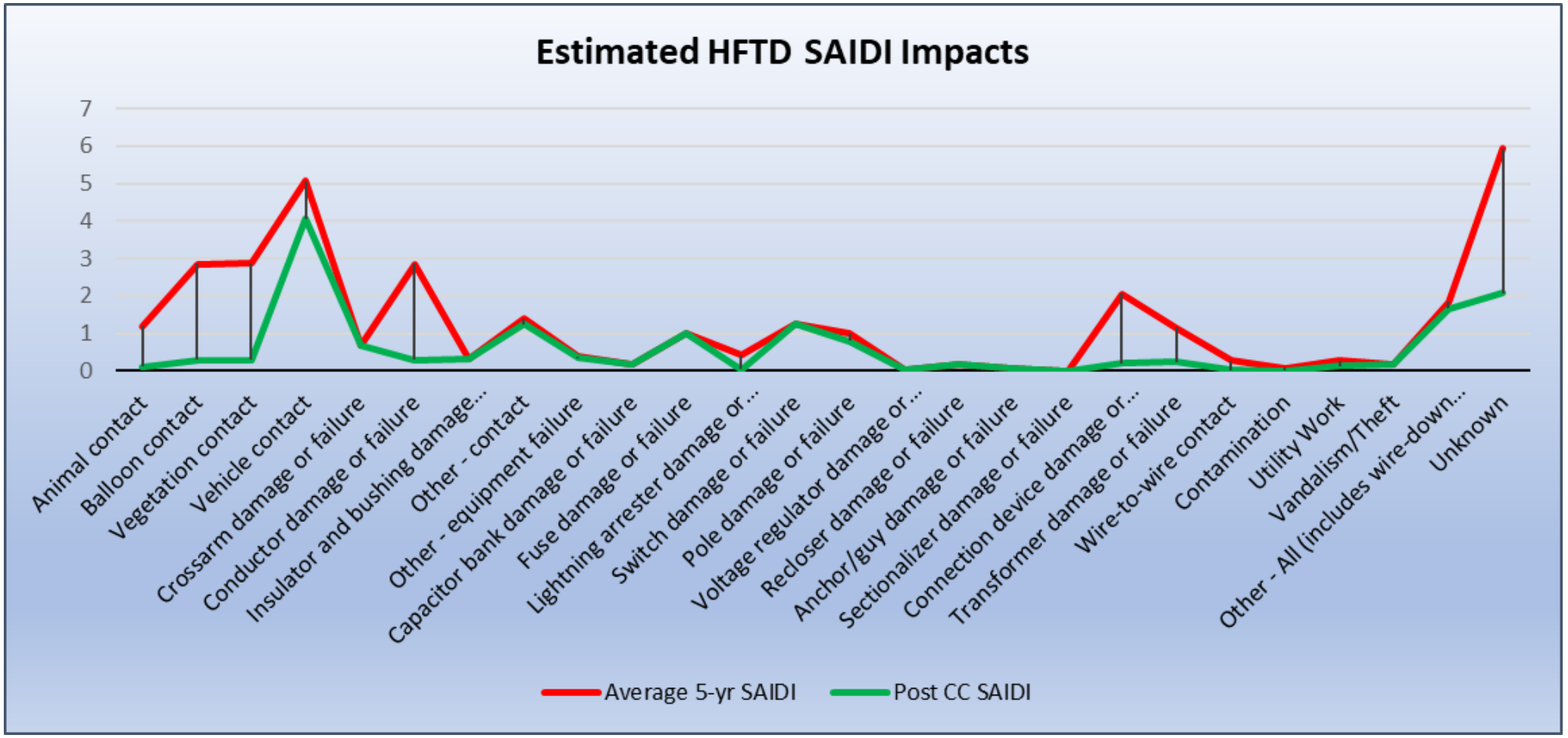
Covered Conductor – Safety

- **NEETRAC Testing**
  - 1/0 CC energized at 12kV
  - Human contact currents measured

	Covered Conductor		Bare Conductor
	Simulation Results	Lab Test Results	Simulation Results
Line Side	0.220 mA	0.227 mA	5,300 mA
Load Side	0.218 mA	0.227 mA	34.2 mA

Current	Effect of electricity on a person
Below 1 mA	Generally, not perceptible
1 mA	Faint tingle
5 mA	Slight shock; not painful but disturbing. Average individual can let go
6-30 mA	Painful shock, loss of muscular control. The freezing current or “let-go” range.
50-100 mA	Extreme pain, respiratory arrest, severe muscular contractions. Death is possible

Covered Conductor – Reliability



Next Steps

- **All utilities are complete with testing, and no additional testing is anticipated at this time.**
- **Testing has been discussed and has informed M&I practices and estimated effectives.**
- **Utilities will monitor if additional testing is needed, based on items that could surface from M&I and share lessons learned.**
- **Propose to cancel future workshops unless there is any additional testing.**