PRESENTED BY

LEO COOMBS

A STRAIGHTFORWARD PRESENTATION OF MGD'S APPROACH TO PROTECTING YOUR ESP AND WHY

OUTLINE

- Power Quality Related Failures
- Power Quality Field Studies
- Differential Mode Noise Examples
- Common Mode Noise Examples
- Common Mode Filters
- Ziton
- Progressive Indication of Failure
- CMF Connection Tips

POWER QUALITY RELATED FAILURES.

ROTOR BEARING FLUTING

ROTOR END RING IN PROCESS OF ELECTROLYSIS

THRUST BEARING FLUTING

ELECTROLYSIS OF MLE IN PUMP HOUSING

PINHOLE IN A CONDUCTOR IN THE STRAIGHT RUN

PINHOLE IN ONE CONDUCTOR

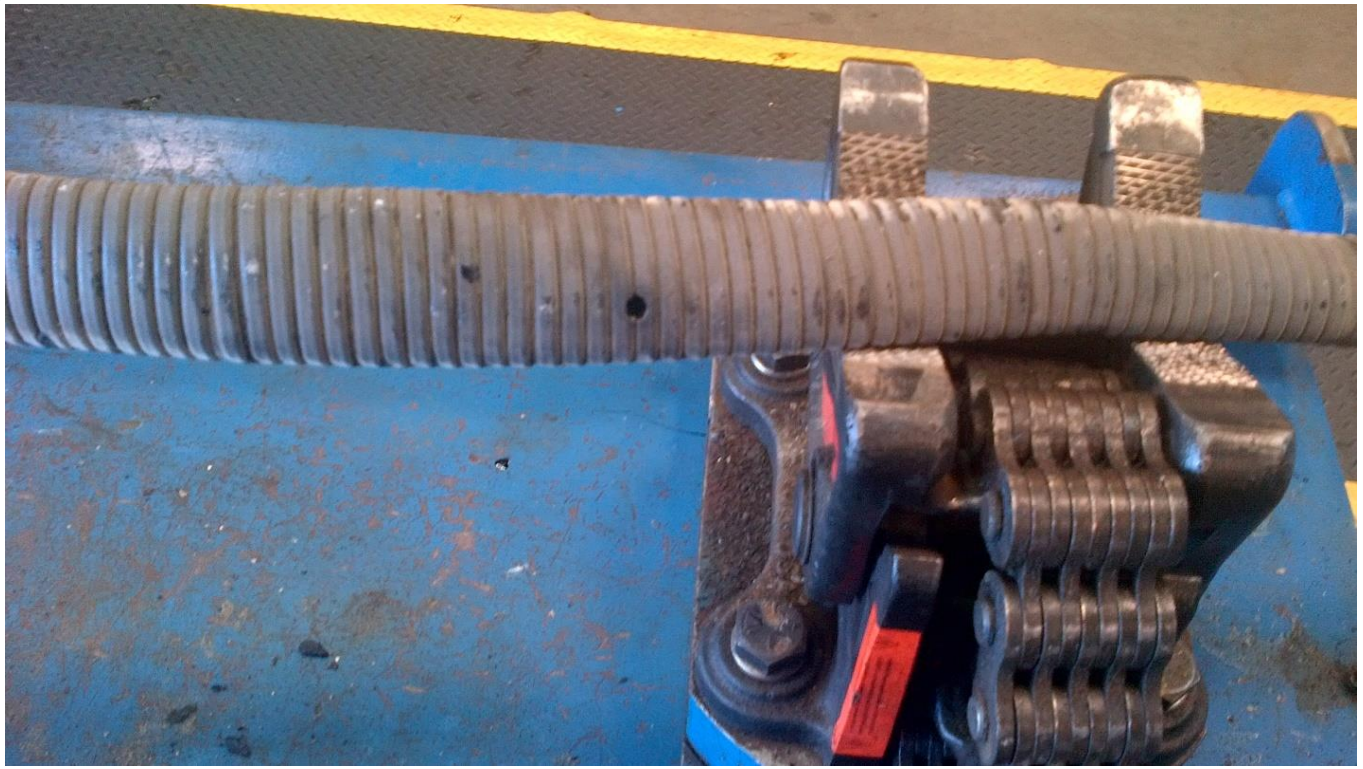
ARCING IN A CONDUCTOR

L-L ARCING AND THEN GROUND FAULT

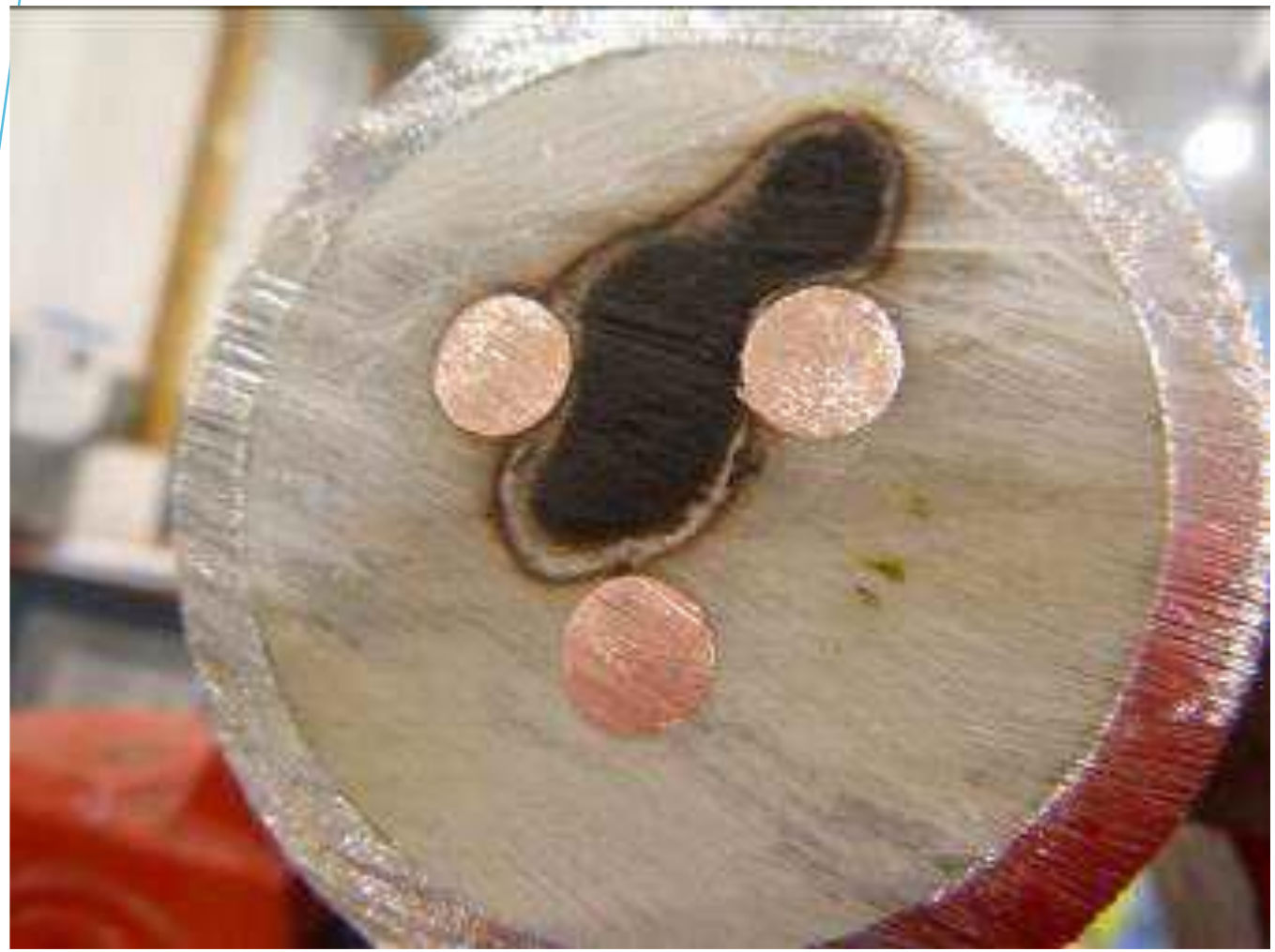
CLASSIC ARCING AND CARBON TRACKING

ARCING IN A CONDUCTOR

MLE FAILURE WITH NO MECHANICAL DAMAGE



PINHOLES IN STRAIGHT RUN OF CABLE



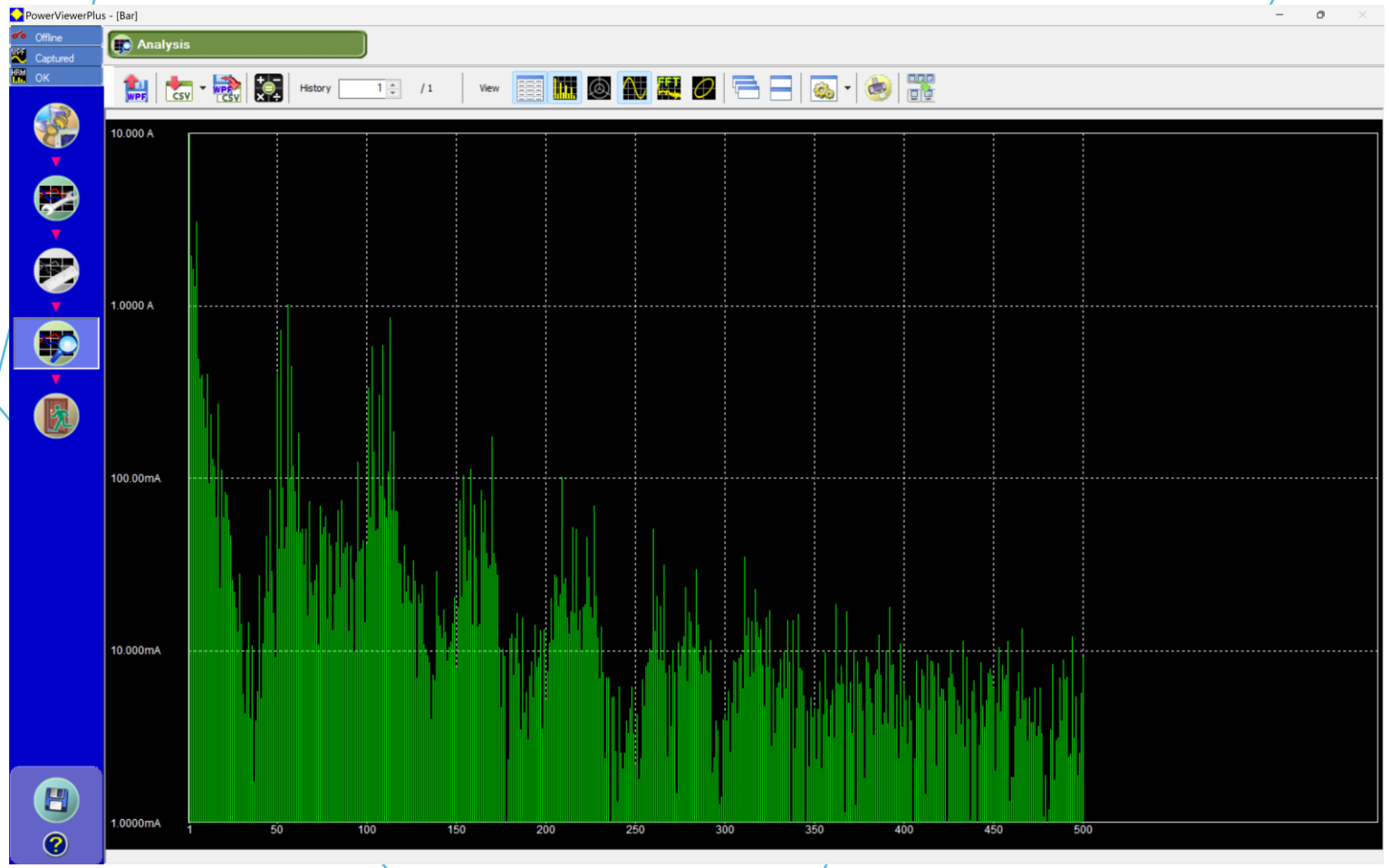
PENETRATOR FAILURE ARCING STARTED L-L AND THEN FAILED TO GROUND

POWER QUALITY FIELD STUDIES – EQUIPMENT CONSIDERATIONS

A standard power quality analyzer, intended for field use, can calculate total harmonic distortion and harmonic magnitudes to the 50th harmonic (+/- 3KHz). This was acceptable in years past.

As PWM carrier frequencies increase, more precise, laboratory grade, equipment is required.

For example, a FPWM ASD operating with a carrier frequency of 3.6KHz places the bulk of the damaging harmonic content as a cluster around the 60th harmonic, when the drive is operating at 60Hz. This is beyond the calculating range of standard power quality analyzers and will not be reflected in either the total harmonic distortion or the harmonics calculations.



POWER QUALITY FIELD STUDIES – HARMONIC ANALYSIS

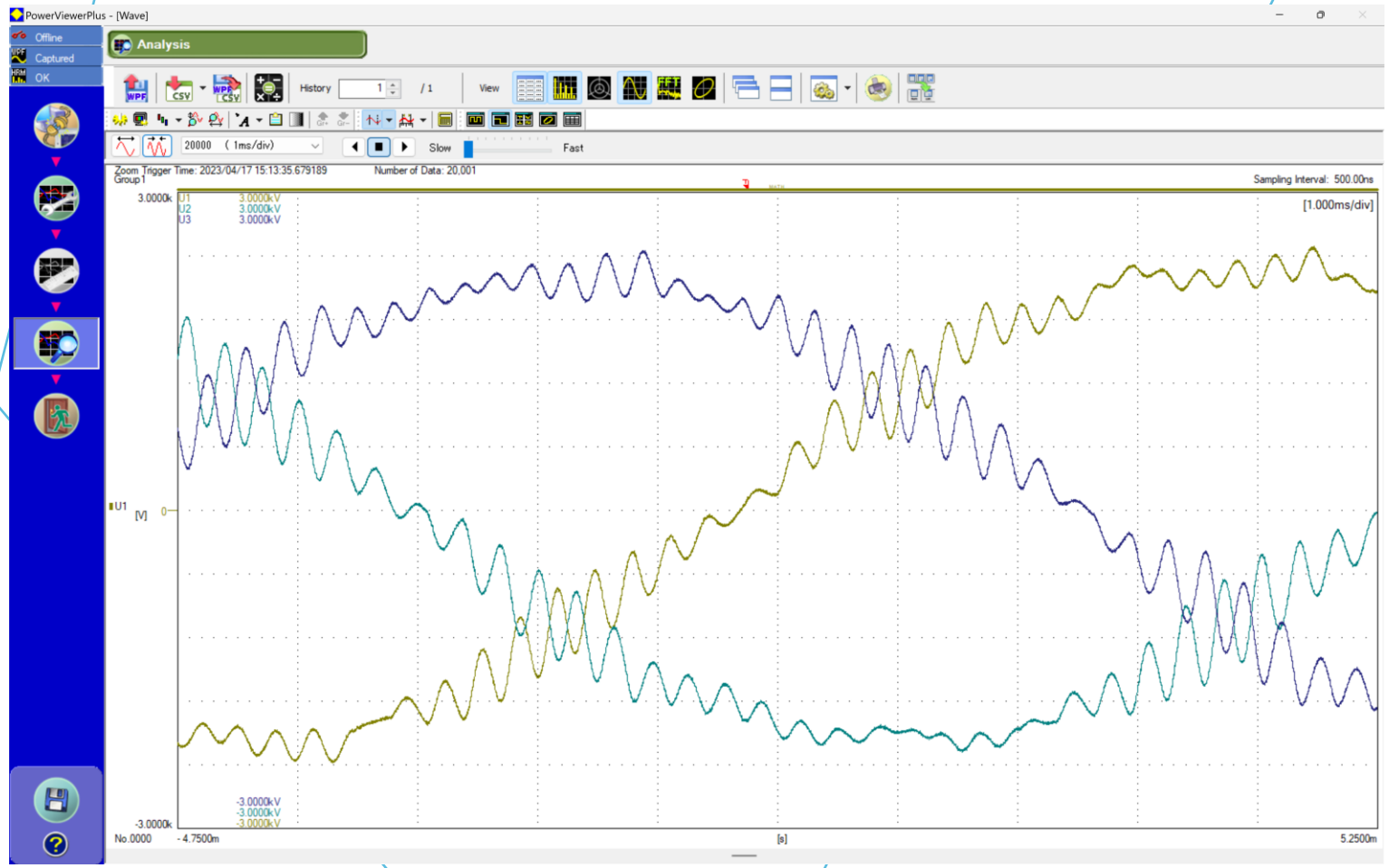
POWER QUALITY FIELD STUDIES – WHEN ARE THEY NEEDED?

Speaking plainly, the true purpose of a field study is to build a case for saving the next iteration of the ESP system. The damage that occurs downhole due to poor power quality can not be undone, but it can be prevented.

Differential mode noise proves repeatedly to cause damage more quickly than common mode noise, but both types of noise will cause damage.

DIFFERENTIAL MODE NOISE

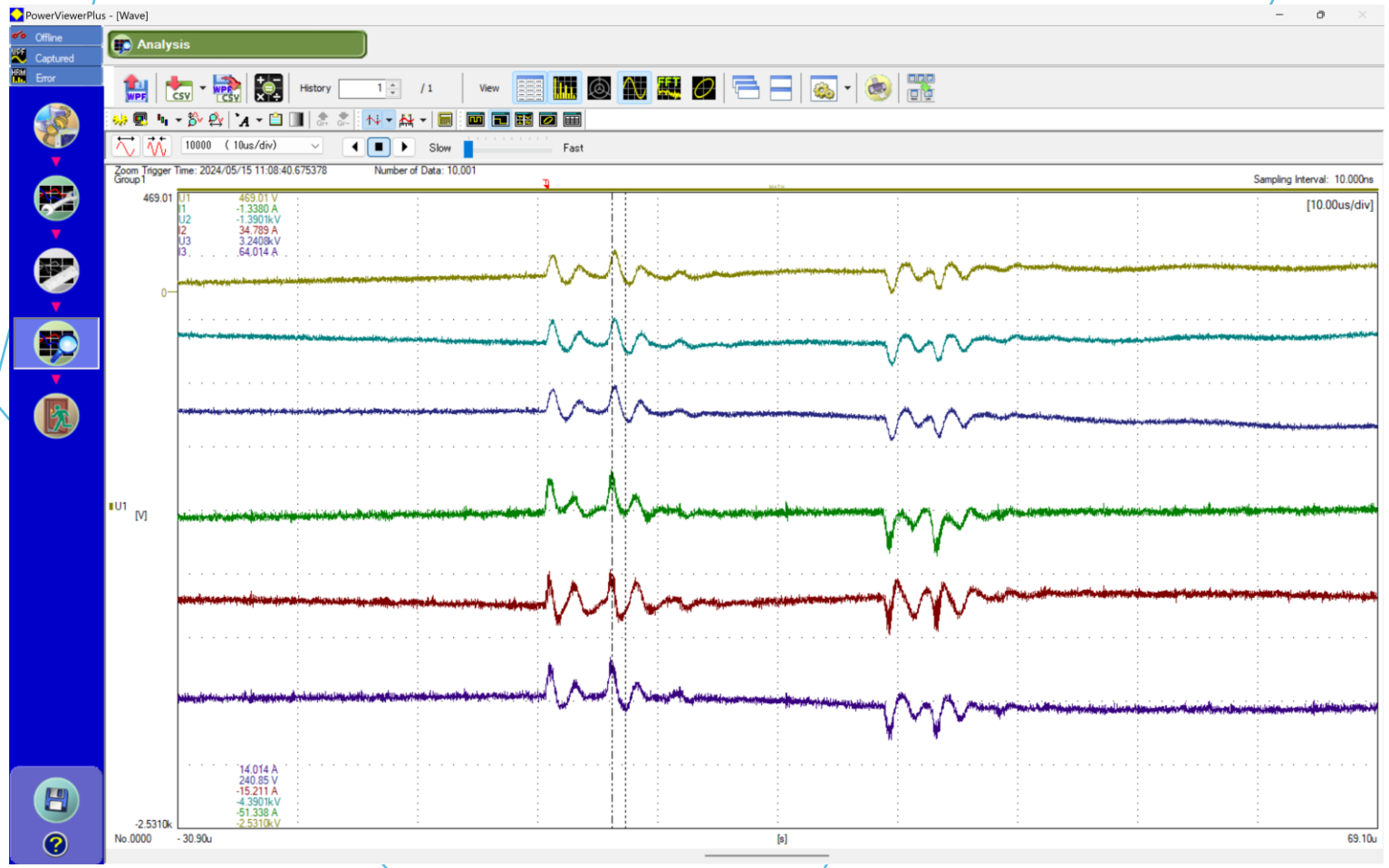
- Noise that occurs phase to phase.
- Greatest observed cause is remnants of PWM switching.
- Mitigated with a healthy sine wave filter which is almost exclusively installed in the ASD.



DIFFERENTIAL MODE NOISE - EXAMPLE

COMMON MODE NOISE

- Noise that occurs phase to ground.
- Greatest observed cause is ASD output switching.
- Mitigated with a common mode filter.



COMMON MODE NOISE - EXAMPLE

COMMON MODE FILTER

- Resistive-capacitive, Y-connected in parallel at the step-up transformer secondary.
- Provides a preferential path for high-frequency imbalances (common mode) to ground.
- Augments the SWF with a small amount of phase-to-phase capacitance.
    - Allows for rapid notification in the event of SFW component failure.

CMF – HOW DOES IT OPERATE? (FPWM) (FUSES 2E FOR VGR2, 3E FOR VGC)

- Starting with a healthy system.
  - The current switch loop will be open prior to start up.
  - Once the drive starts, a small amount of high frequency begins to flow through the CMF to the ground connection.
    - Once this reaches approximately 1/8th amp of high frequency, the current switch loop closes.
      - Depending on the drive, this can take a few seconds. Recommend a two-minute delay as the amount of high frequency can drop below this, in rare instances, with a pristine drive running in PID mode.
  - If the current switch loop changes state during operation, this indicates a fuse is blown in the CMF.
    - Observation indicates this is almost always due to a failed/failing capacitor in the SWF of the Drive.
      - Change the capacitor(s) in the SWF, replace the fuse in the CMF, and start back up.
      - There is nothing I've seen that catches SWF capacitor failure faster than the CMF.
- The temperature switch loop opens in the event one of them detects a temperature greater than 350F.

CMF – HOW DOES IT OPERATE? (6-STEP) (VGC ONLY, 5E FUSES)

- Starting with a healthy system.
  - The CMF is no longer acting as a common mode filter but as a Resistive-Capacitive Snubber circuit.
    - It helps to ring out the switching transient of the square wave more quickly.
    - The current through the CMF will stay steady at approximately 3.5 amps of high frequency and stay there as there is no SWF failure event to cause a change in state.
- The temperature switch loop opens in the event one of them detects a temperature greater than 350F.

CMF - FAQ

- Why is the CMF making my drive fail?
  - The CMF isn't making your drive fail. I haven't seen this yet.
    - Check that the CMF was installed properly against the installation instructions located in every new CMF.
- Why is the CMF causing a ground in the ESP?
  - The CMF isn't causing a ground downhole.
    - The first indication of a downhole ground is a loss of downhole comms.
    - The CMF shunts a significant amount of high frequency noise to ground with some drives.
      - This noise on the ground can confuse the downhole comms.
  - Relocate the CMF ground connection so it is not shared with the downhole choke.
    - Verify the quality of the site's grounding.

CMF - FAQ

- The current switch loop isn't closing after start-up. What's the problem?
  - Check that the CMF was installed properly against the installation instructions located in every new CMF.
  - Check the state of the fuses.
- A fuse keeps blowing in the CMF. What's the problem?
  - Check that the CMF was installed properly against the installation instructions located in every new CMF.
  - Check the capacitors in the SWF of the drive.
    - Remember that the typical capacitors used in the SWF are of a style with internal contacts that open in the event of excessive heat. They can reclose and test good after shutdown and enough time to cool.

CMF - FAQ

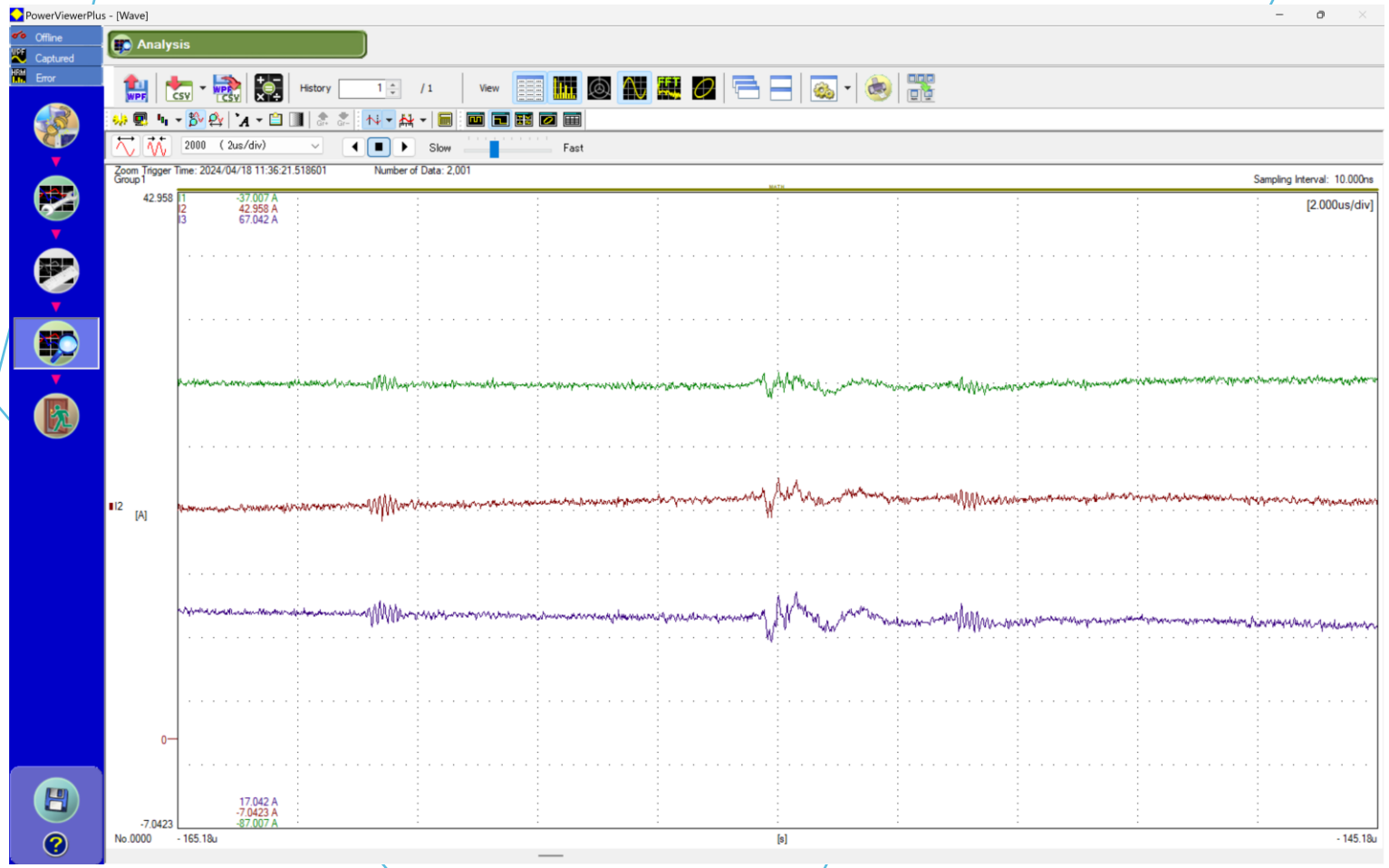
- Why can't I put 5E fuses in my VGR2? (smaller unit)
  - The time it takes for the 5E fuse to open in the event of SWF failure is sufficient to melt components in the CMF.
- Why can't I use 5E fuses in the VGC when used with a FPWM drive? (larger unit)
  - The time it takes for the 5E fuse to open in the event of SWF failure is sufficient to melt components in the CMF.
- Okay, then why is it okay to use the 5E fuse in the VGC with a 6-Step drive? (larger unit)
  - The current through the CMF will stay at approximately 3.5 amps of high frequency.
  - There is no SWF to fail and cause the CMF components to melt.
    - The CMF will run hotter than usual and may show some indication of heat over time.

CMF - FAQ

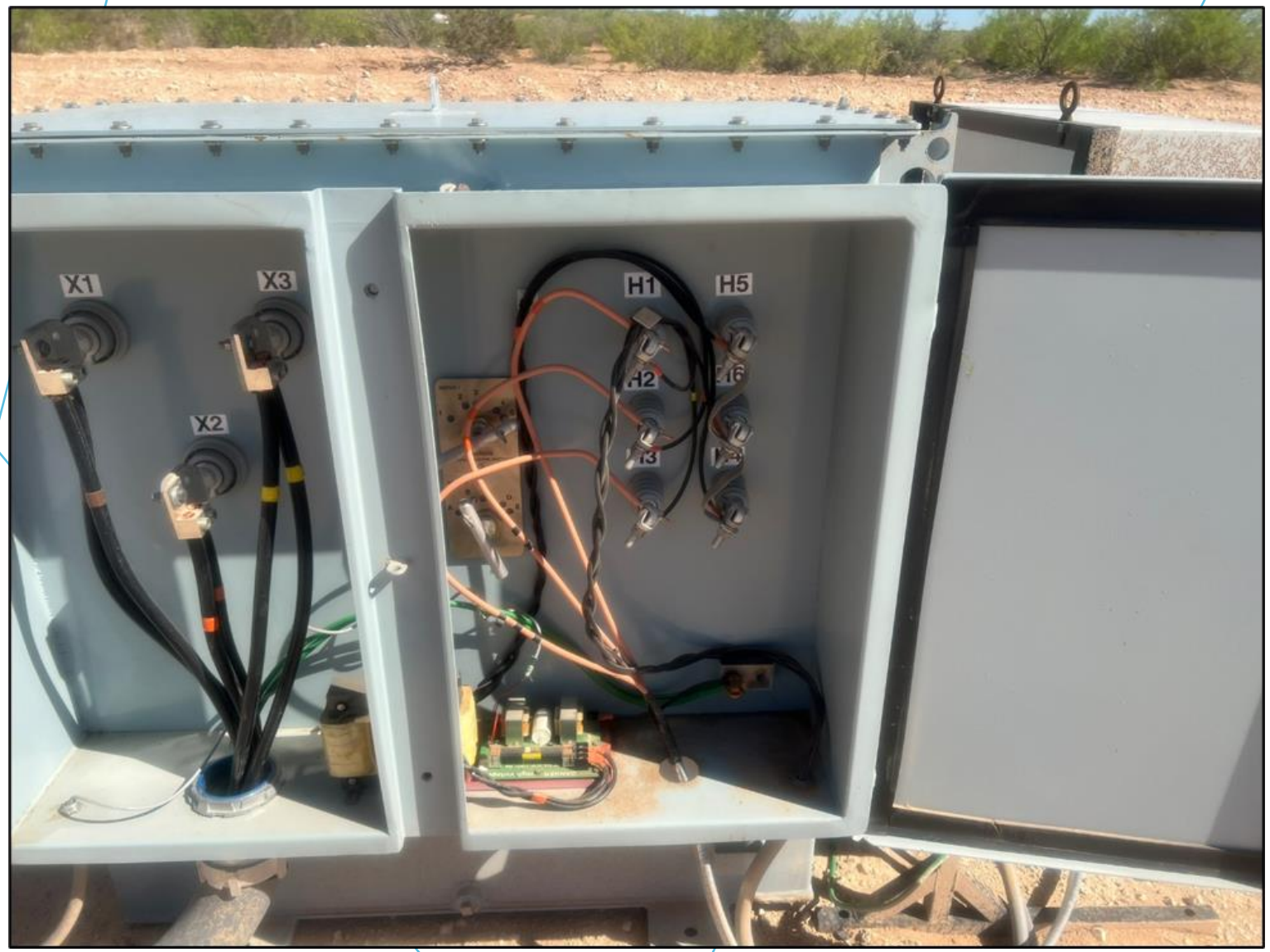
- The drive is running and the current switch lights are lit, but the current switch loop is open. How is this even possible?
  - The loop is broken somewhere. Check continuity of the loop leg by leg giving special emphasis to being certain the connections in the terminal block are tight.

ZITON

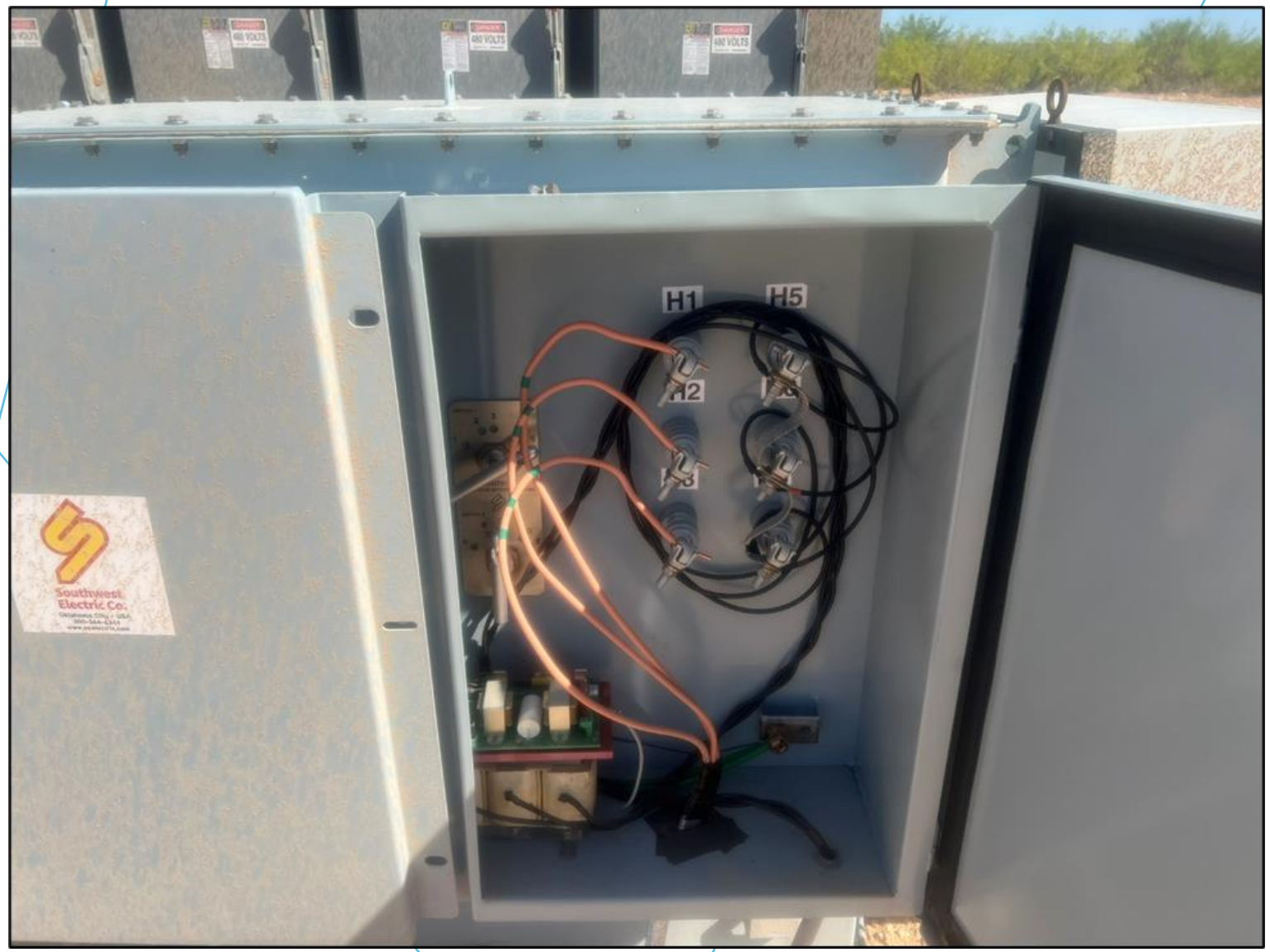
- Ziton is a meter that provides basic electrical measurements locally and remotely using Modbus protocol.
- Low voltage and medium voltage models are available.
- Provides:
  - Voltage (phase-to-phase and phase-to-ground)
  - Current
  - Power (KVA, KW, KVAR)
  - Power Factor
  - THD
- Limitations
  - Currently unable to detect SWF component failure.
  - Not certified as a power meter.



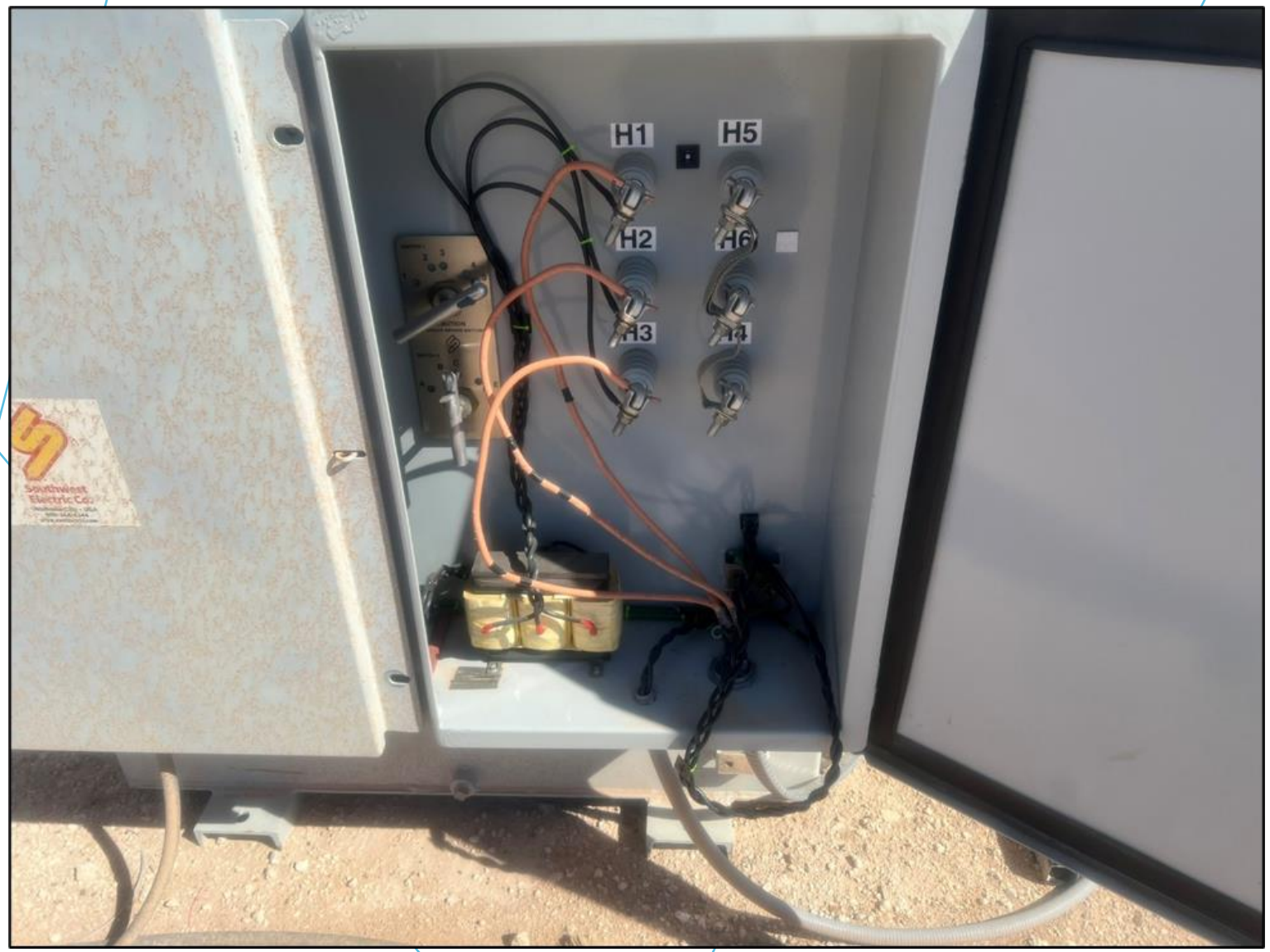
PROGRESSIVE INDICATION OF ESP INSULATION FAILURE



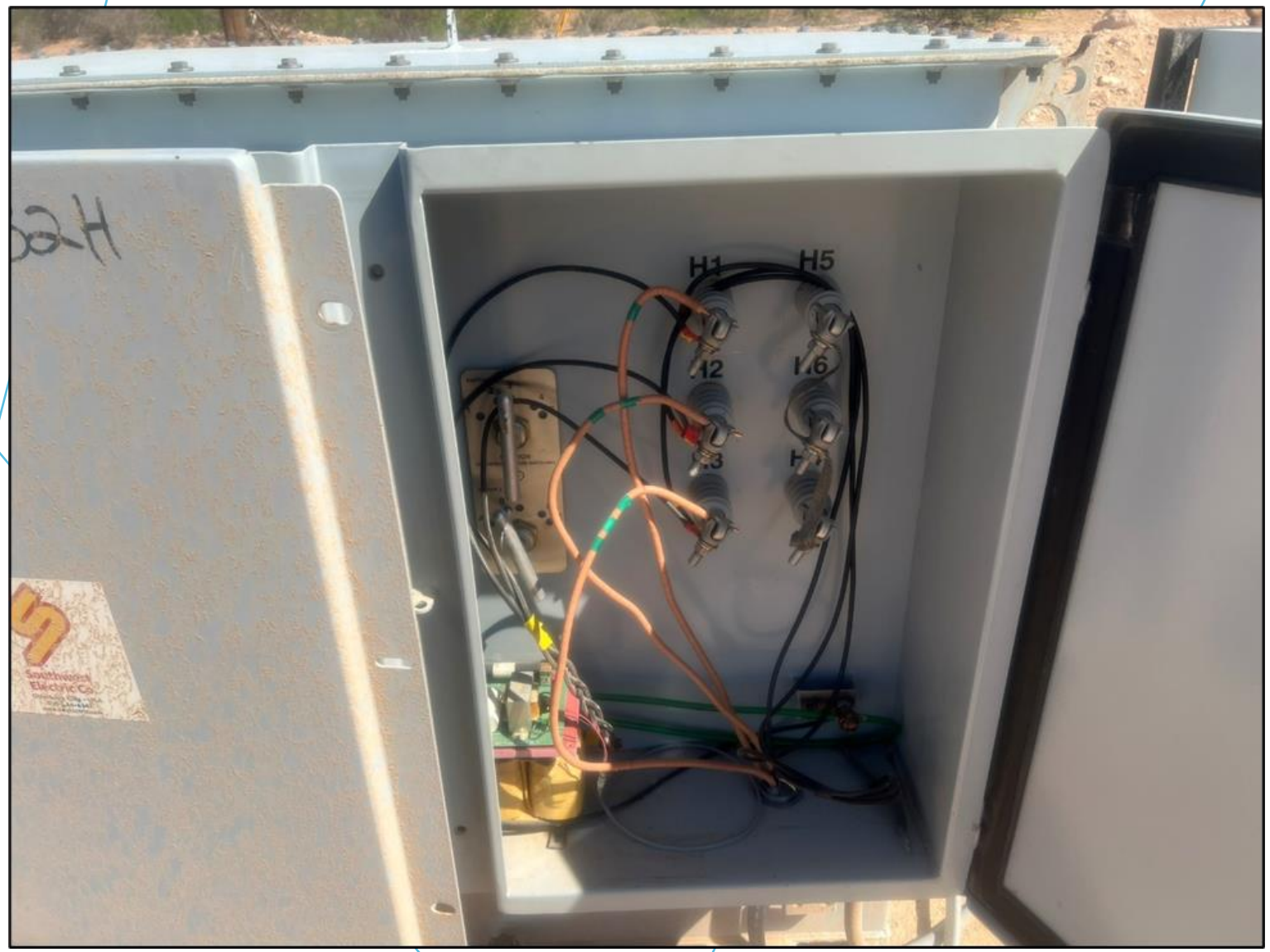
CMF - INCORRECT CONNECTION



CMF – INCORRECT CONNECTION



CMF – INCORRECT CONNECTION



CMF – CORRECT ENOUGH

QUESTIONS?

Leo Coombs

VP Engineering

MGD

leo@magneygrande.com