Decoupler Interaction with CP Systems

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Appalachian Underground Corrosion Short Course

Agenda

- Decoupler operation and response
- Close interval surveys
- Coating surveys using DCVG
- Locating signals and pipeline current mapper
- Insulation testing devices

What is a Decoupler?

- Device with very low impedance to AC but blocks DC up to a predetermined voltage level, typically 2 to 3 volts
- Typical AC impedance: 10 milliohms
- Typical DC resistance: Megaohms
- Solid-state construction, two terminal device
- Connects between pipeline and ground, or other structure

What is a Decoupler?

Connecting decoupler between pipeline and ground:

- Virtually the same as direct bonding for AC
- DC isolates the grounding system from the pipeline CP system (maintains CP)
- Provides over-voltage protection (AC faults, lightning)
- Addresses grounding requirements

Typical Decoupling Devices

How Do Decouplers Work?

- Present very low impedance to AC via significant capacitance
- If 10A AC-rms flows through 0.01 ohm decoupler, resulting peak voltage is:

  $10A \bullet 0.01\Omega \bullet 1.414 = 0.14V$

- This value is below the voltage threshold

How Do Decouplers Work?

- Typical V_{DC} difference is around 1V
- Direct current (CP) does not flow, if below the voltage threshold
- If VDC + VAC peak < threshold voltage, decoupler blocks CP and is in normal mode
- CIS effects related to decouplers do not relate to “switching them on” – this doesn’t occur

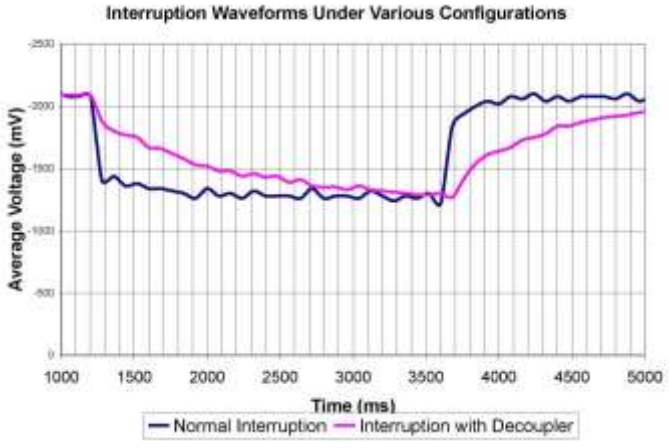
How Do Decouplers Work?

- Voltage of interest is value between the decoupler terminals, value between two structures
- Pipe-to-soil voltage is different value
- CP voltage across decoupler is present when instant off operation occurs

CIS Conditions

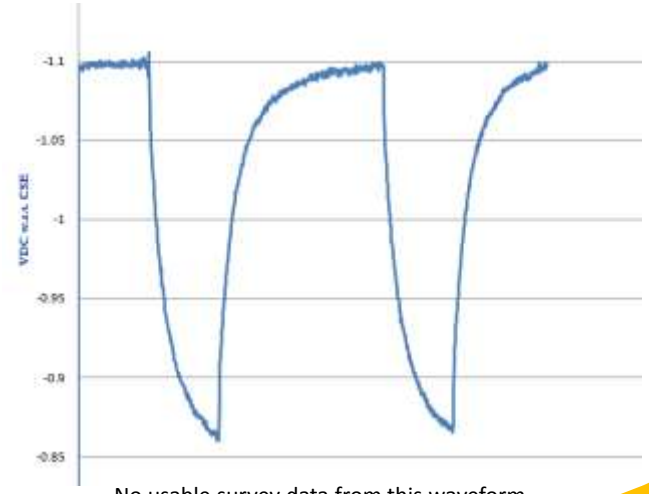
- Interrupted surveys create fast changes in DC voltage
- Apparent voltage appears a step change
- Capacitance of system (decoupler, coating, etc.) doesn't allow voltage to change quickly
- Result can slow down waveform changes
- Recording equipment then captures VPS too electro-negative vs. real value

Waveform Example



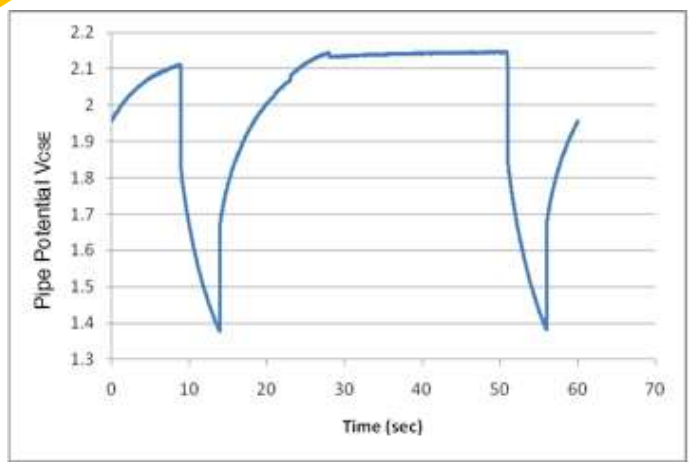
Measurements on a 6"- 40 mile, 16 mil FBE well coated pipeline

Waveform Example



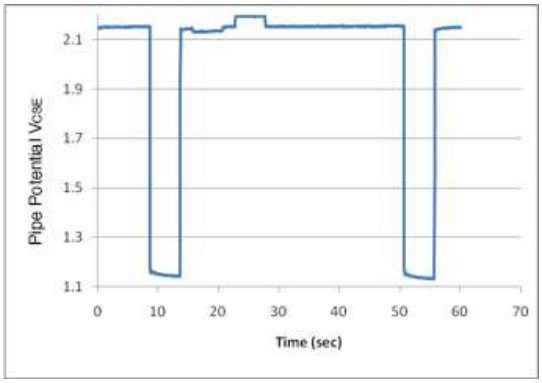
No usable survey data from this waveform

Waveform Example



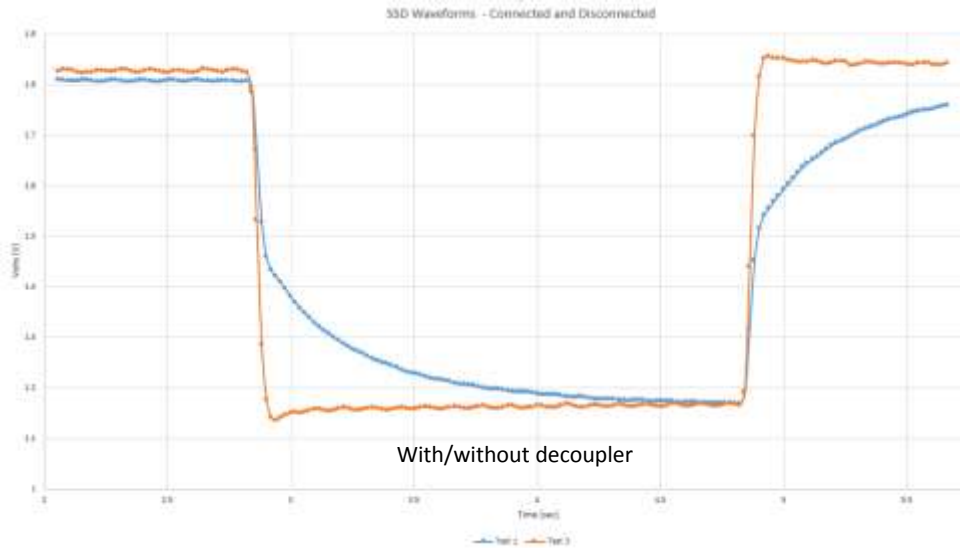
Two decouplers near valve – unacceptable OFF condition

Waveform Example



Same as previous slide, but with two decouplers removed

Waveform Example



With/without decoupler

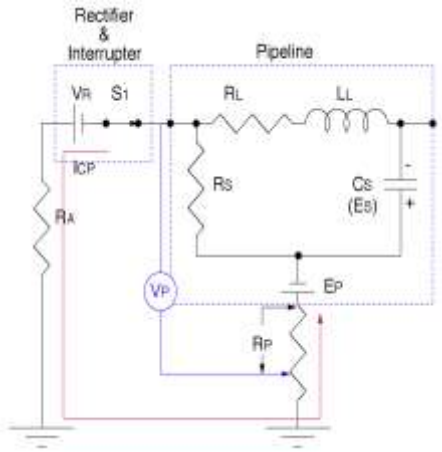
Why Does This Occur?

- Voltage difference present across capacitance of system when ICCP source is removed
- Current will flow as result of voltage present
- Appears as an uninterrupted source
- Until current dissipation, voltage measurement will be in error to a degree

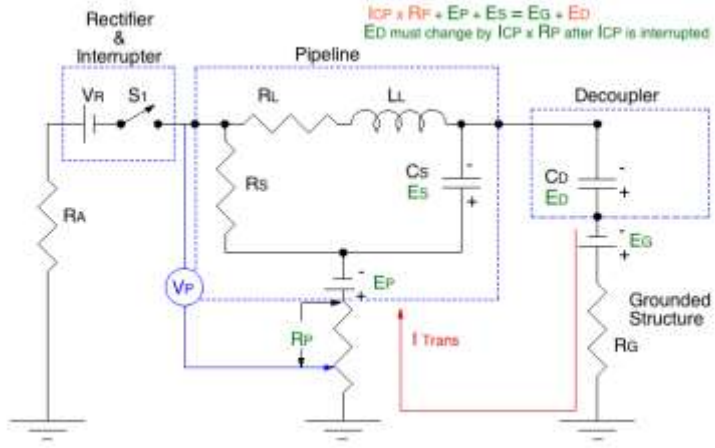
Why Does This Occur?

- Dissipation time dependent upon circuit RC time constant
- R primarily pipe-to-soil resistance
- R decreases with longer, larger diameter pipelines
- C primarily decoupler capacitance, but also coating capacitance

Effective Circuit – ICCP System



Effective Circuit – With Decoupler



Why Does This Occur?

- If mitigation is excessive, results in more decouplers than necessary
- Decoupler capacitance values are additive when closely spaced
- Coatings are greatly improved (higher resistance)
- Greater use of off potential criteria

Easy Solutions Not Acceptable

- Removing decoupler from system results in no over-voltage protection for faults, lightning
- Removal eliminates AC mitigation; VAC jumps to pre-mitigation levels; may affect CP readings
- Drastic capacitance change conflicts with need for collapsing AC voltage to low levels: voltage directly tied to capacitance
- NACE SP0177 guidance: 15V limit
- AC corrosion concerns

Realistic Solutions

- Adjustment of voltage reading capture time
  - Take reading later in same OFF cycle
- Adjustment of rectifier cycling periods
  - Longer OFF period allows waveform to stabilize
- Use of correlation factors, such as IR free coupons for independent verification
- Disconnection of decouplers for testing

Interruption Warning

- Isolating decoupler from pipeline removes AC mitigation system
- AC voltage on pipe will increase
- Increases with additional decouplers removed
- Wire from pipe (or isolation switch terminal) will be at pipeline AC voltage
- Minor arcing will occur as system is disconnected/reconnected with associated current flow

DCVG Surveys

- Cycling ICCP system provides means of detecting voltage gradient due to current flow at defects
- Similar to CIS, decoupler has current flow during capacitance discharge
- Local disconnection of decoupler addresses issue; not large effect upon AC mitigation if only one device removed
- Use disconnect switch

Locate Signals, Current Mapping

- Various frequencies applied: 4Hz, 98Hz, 4kHz
- Decoupler seen as a low impedance by such signals
- Appears as lower impedance to increasing frequencies
- Passes signals at point of decoupler connection to pipeline
- Temporary local disconnection possible

Source: Radiodetection

Isolator Testing Devices

- 221kHz RF signals used for detection of shorted joints
- Signal application to one side, detect presence on other side
- Decoupler is connected between same points, passes signals
- Detects as failed, decoupler removal tests as good; user incorrectly assumes decoupler has failed

Source: Tinker and Rasor

Decoupler Testing

- "Normal" CP voltage reading to reference cell by corrosion personnel indicates correct decoupler operation
- A shorted device won't support adequate CP readings, hence this easy indicator
- Actual failure is very rare
- Can test using multimeter on resistance setting – see testing instructions

Conclusions

- Consider various signals used near decouplers, and their effects
- Understand how decouplers function
- Check interrupted waveforms before proceeding with close interval surveys
- Disconnect decouplers safely when AC induction present