2.0 Cable Injection Technology
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Agenda

• Masters of Reliability
• What is Cable Rejuvenation?
• Sustained Pressure Rejuvenation
• Economics
• Innovation
• Case Studies
• Q&A, Discussion
Masters of Reliability –

Who is Novinium?

• Headquartered in Auburn, WA
• Regional office in Raleigh, NC
• > 8 million feet injected; 99.6% post-injection success rate
• 25+ years of experience in technology; Over 30 patents granted or pending
• State-of-art research facilities, focus on R&D
• P1816 IEEE Partnership
What is Cable Rejuvenation? – Why do cables fail?

Manufacturing defects & flaws

Dirt

AC stress

Water

Water trees

Flaw

Water trees

Electrical tree characterized by large channels
What is Cable Rejuvenation? – Overview

- Cable Rejuvenation introduces silicone fluid into power cable strands
- Deployed via low to moderate pressure injection
- The fluid migrates into the conductor shield and insulation
- Injection fluids modify the chemistry of the insulation and the physics of the cable to extend the reliable life of the circuit
- Injection team personnel is flexible
Fluid flows readily through strand interstices ...

... and diffuses into plastic
Failure Mechanisms

- AC stress
- Ions
- Water
- Water trees
- Local high-density: space charge & e-field
- Transient over-voltage
- UV emission
- Hot electron acceleration
- Void formation (electrical trees)
- PD (partial discharges)
- Stress grading
- Voltage stabilization
- UV stabilization
- Antioxidation
- PD suppression
- Manufacturing defects
- Nanovoid filling
- Drying
- Thermo-mechanical stress
- Void formation
- Failure
SUSTAINED PRESSURE REJUVENATION (SPR)

Advanced Cable Injection

2\textsuperscript{nd} Generation Technology
Sustained Pressure Rejuvenation –
Process Basics & how it differs from 1.0 product

- Fluid is injected and confined to cable segments under tailored, moderate pressure (no soak)
- Standard elbows and splice kits are used
- Accessories are not exposed to fluid
- Pressure increases diffusion, creating significant positive effect on dielectric recovery time: 7 days
- Excavation and replacement of splices
- 40 Year Unconditional Warranty (Ultrinium™)
- Post injection failure rate = < ½%
Sustained Pressure Rejuvenation

- De-energize, Test & Ground Cable (A-B)
Sustained Pressure Rejuvenation

- De-energize, Test & Ground Cable (A-B)
- Perform TDR – Locate Splices – Collect Data
Sustained Pressure Rejuvenation

- De-energize, Test & Ground Cable (A-B)
- Perform TDR – Locate Splices – Collect Data
- Remove Terminations & Connectors

Use connector cut-off tool to preserve conductor

Transformer A

Transformer B

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Sustained Pressure Rejuvenation

- De-energize, Test & Ground Cable (A-B)
- Perform TDR – Locate Splices – Collect Data
- Remove Terminations & Connectors
- Position New Connectors and IAs
Sustained Pressure Rejuvenation

- De-energize, test & ground cable (A-B)
- Perform TDR – Locate Splices – Collect Data
- Remove terminations & connectors
- Position new connectors and injection adaptors
- Swage Injection Adaptors & Connectors
Sustained Pressure Rejuvenation

- De-energize, test & ground cable (A-B)
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- Swage Injection Adaptors & Connectors
- Install Injection Tools
- Inject Segment At Moderate Pressure

Transformer A
Transformer B
Flush tank

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Sustained Pressure Rejuvenation

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- Swage Injection Adaptors & Connectors
- Install Injection Tools
- Inject Segment At Moderate Pressure
- Complete Installation Of Terminations

Slide standard termination over injection adaptor

Transformer A

Transformer B
Sustained Pressure Rejuvenation

- De-energize, test & ground cable (A-B)
- Perform TDR – Locate Splices –
- Collect Data
- Remove terminations & connectors
- Position new connectors and injection adaptors

Transformer A

Transformer B

Swage Injection Adaptors & Connectors
- Install Injection Tools
- Inject Segment At Moderate Pressure
- Complete Installation Of Terminations
- Re-energize

Single Visit – Single Switch™
7 Day Dielectric Recovery
40 Year Warranty

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Sustained Pressure Rejuvenation

Splice Present?

Transformer A

Flush tank

Transformer B

Pit

swage

feed tank x 2

Flush tank

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## Economics – Typical problems solved

<table>
<thead>
<tr>
<th>Problems You Face</th>
<th>Rejuvenation Outcomes Achieved</th>
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<tbody>
<tr>
<td>Declining cable reliability</td>
<td>Same reliability as new cable in a fraction of the time</td>
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<tr>
<td>Spending more than $20/ft to solve power cable</td>
<td>50% cost reduction</td>
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<tr>
<td>reliability problems</td>
<td></td>
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<td>Insufficient Maintenance budget for cable failures</td>
<td>Shift cost of cable failures from O&amp;M $ to CAPITAL $</td>
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FERC & RUS approved for segment-by-segment expense capitalization
Innovation –
Total Reliability Approach, Maximize Capital Use

- No segment left behind
  - Blended methodology
  - Rejuvenation + Replacement
- Accessory upgrades
  - Elbows, connectors, splices
- Transformer inspections
- GIS updating
Innovation – Method & Economics

Rehabilitation = Rejuvenation + Replacement

Rehabilitation cost decreases with aggressive splice replacement

Rejuvenation cost increases with aggressive splice replacement
Case Study –
Gainesville Regional Utilities (GRU)

• Key Project Stakeholders
  – General Management
  – Engineering & Operations
  – Standards & Purchasing

• 93,000 customers; 5th largest muni in FL

• 101 year old utility, aging underground infrastructure

• Replacement program ramping up out of necessity, fault rate increasing by 2.5% annually
Case Study – Gainesville Regional Utilities (GRU)

- Injection Technology Concerns
  - Neutral corrosion
    - Perception vs. Science
  - Water in cable
    - Wet soil = water logged cable
    - Unfamiliarity, Post-Injection reliability concerns
      - Adoption hesitance

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Case Study – Gainesville Regional Utilities (GRU)

- 8/2011 through 11/2012
- GRU craft, Novinium leader
- Cable Feet Scope: 148,868 feet
  - 1/0, #2, 1000mcm
- Cable Feet Injected: 126,443
  - 85% success rate on cables provided vs. injected
  - Faults down 12% system wide in 2012, mid-year projections predict a 20% for 2013
  - NI’s: Local corrosion, stranded/solid cable, inaccessible splices
Case Study –
Gainesville Regional Utilities (GRU)
Cost comparison: Rehabilitating 148,868 feet of cable

20% of the cost of total replacement

Injection  Replacement

$
Case Study –

Major Investor Owned Utility (Mid Atlantic U.S.)

- Blended, Total Reliability Approach

January - November 2012 Injection and Replace Savings

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<tr>
<th>Novinium Rejuvenation/Replace</th>
<th>Traditional Replacement Approach</th>
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<td>Feet</td>
<td>Rate</td>
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<tr>
<td>Inject 527,051</td>
<td>$</td>
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<tr>
<td>Replace 59,926</td>
<td>$</td>
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Savings over Replacement $8,819,663
Discussion –

• Q&A
• Contact information:

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