Underground Medium Voltage Cable Testing

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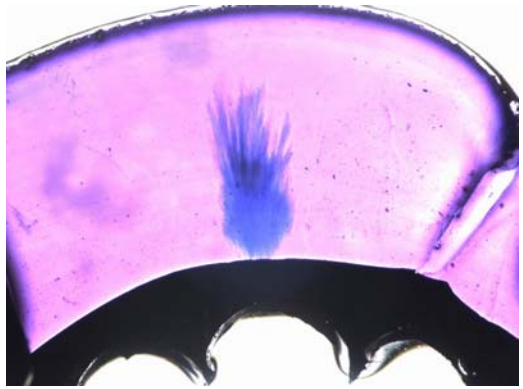
TVAN MV Cable Program

- Concern for water treeing
  - Water
  - Contamination
  - Voltage stress
  - Time
- Rigorous failure analysis
  - Beginning in late 1980s
- Field testing
  - Beginning in 2003
- Industry involvement
  - IEEE/ICC
  - EPRI



MV Test Program Issues

- Selection of test method and acceptance criteria
  - Not DC (damaging and not sensitive)
  - Must be tailored to expected degradation
  - Must be matched with insulation system
- Training
  - Loss of experienced workers
  - Infrequently used skills
  - New technologies
- Selection of cable accessories
  - Splices, terminations and separable connectors
  - No impact on test, quick application, low risk removal
- Replacement cable strategy
  - Up-to-date cable specs – AEIC CG-10
  - Conventional
  - Moisture impervious – IEEE 1142
    - Eliminates the need for repetitive testing

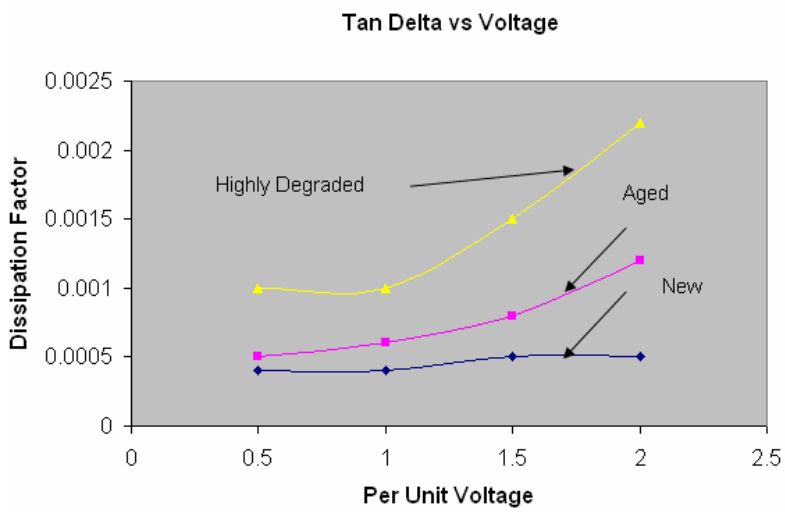
MV Cable Test Equipment

- Desired attributes
  - Meaningful test
  - Non-damaging to otherwise sound insulation
  - Portable
  - Ease of use
  - Low cost
  - Supported by industry standards

- Selected methodology
  - Very low frequency (0.1 Hz) AC HV power supply
  - Tan delta bridge for condition assessment
    - Measures ratio of resistive current to capacitive current
  - $35,000
  - 45 lbs

VLF/Tan Delta Testing

- Condition assessment (tan delta)
  - Evaluates global condition
  - Acceptance criteria defined for XLPE by IEEE
  - 0.5, 1, 1.5 and 2 times rated voltage to ground
  - New cable – provides baseline
  - Aged cable – indicates age condition
  - Not a timed test, typical 2-5 minutes
- Dielectric integrity withstand test
  - Identifies local defects
  - Go/no-go
  - Typically 2-3 times rated voltage to ground
  - New cable - 30 minutes
  - Aged cable – 15 minutes



MV Cable Test Results

- SQN – initial testing complete
  - Tested 304,000 conductor feet (196,000’ aged, 108,000’ new)
  - Approximately 275 tan delta measurements (multiple segments per circuit)
    - Portions of 12 circuits exceeded end-of-life criteria
    - Many re-tests early in the program: poor prep, poor setup and marginal equipment
  - Approximately 160 withstand tests
    - 2 breakdowns during re-tests of highly aged cable
- BFN – first round assessments nearing completion
  - Tested 38,000 conductor feet (25,000’ aged, 13,000’ new)
  - Approximately 190 tan delta assessments (multiple segments per circuit)
    - 6 circuits exceeded end-of-life criteria
    - Very few retests: better training, better equipment
  - Approximately 185 withstand tests
    - 1 breakdown
- WBN – program just beginning
  - Tested 1650 conductor feet (all aged)
  - 3 tan delta measurements, no failures
  - 3 withstand tests, no failures
- No in-service failures of tested cables since program inception

Resources

- AEIC Cable Guide
  - AEIC CG-10, *Guide for Developing Specifications for Extruded Power Cables Rated 5 through 46 kV*
- IEEE Insulated Conductors Committee
  - http://www.ewh.ieee.org/soc/pes/icc/
- IEEE Standards
  - IEEE 400 - *Guide for Field Testing and Evaluation of the Insulation of Shielded Power Cable Systems*
  - IEEE 400.2 - *Guide for Field Testing of Shielded Power Cable Systems Using Very Low Frequency (VLF)*
  - IEEE 400.3 - *Guide for Partial Discharge Testing of Shielded Power Cable Systems in a Field Environment*
  - IEEE 1142, *Guide for the Selection, Testing, Application and Installation of Cables Having Radial Moisture Barriers and/or Longitudinal Water Blocking*
- EPRI Technical Reports
  - 1003664 - *Medium Voltage Cable in Nuclear Plant Applications*
  - 1013187 – *LCM Planning Sourcebook: Medium Voltage Cables and Accessories*
- EPRI-PSE Cable Users Group
- NEI 06-05 - *Medium Voltage Underground Cable White Paper*