Recap Of December 2007 EPRI Cable Users Group Meeting

Robert Konnik

ROCKBESTOS SURPRENANT CABLE CORPORATION
ENGINEERED WIRE AND CABLE

Electric Power Research Institute

- Established in 1973
- Independent, nonprofit center for public interest in energy and environmental research
- EPRI brings together members, participants, the Institute's scientists and engineers, and other leading experts to work collaboratively on solutions to the challenges of electric power

EPRI

- These solutions span nearly every area of electricity generation, delivery, and use, including health, safety, and environment
- EPRI's members represent over 90% of the electricity generated in the United States
- International participation represents nearly 15%

EPRI Cable Users Group

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Technical Presentations of Dec 2007

- Line Resonance Analysis (LIRA) Update
- Generic Letter 07-01
- Fiber Optic Cable and Nuclear Plants
- Class 1E LSZH Cable
- DG-1132 Update
- MV Cable Systems Training Course
- Medium Voltage Cable Testing

Technical Presentations of Dec 2007

- Rejuvenation of MV Cable by Injection Process
- MV Cable Specifications
- MV Failure Mechanism Assessment
- MV Cable Aging Management Guide
- Condition Monitoring of LV Cables

Line Resonance Analysis

LIRA

Line Resonance Analysis (LIRA)

- New Test For Detection of Cable Aging and Damage
- Developed by The Halden Reactor Project
- High Frequency Low Voltage Tests That Assesses Reflected Impedance
- Local Damage and Bulk Thermal Aging
- Hot Spots

Data

- Shows Relative Position of Hot Spot, Damage or Splice
- Need Cable Length or Relative Phase Velocity to Pinpoint
- Varies by Material and Manufacturer
- May be Configuration Dependant

Equipment

- Portable
- Computer and Signal Generator/Impedance Analyzer
- Additional Computer May be Used for Simulations

Tests – Cuts and Gouges

- Cuts and Gouges in Single or 2 Conductors of 3/C or 2/C Cable
- Straight Samples Found Wet or Dry
- When Coiled Most Only Found Wet
  - Maybe Noise
  - Not Plant Configuration

Tests – Thermal Aging

- Aged Near End of Life
- Found Damage
- Maybe Correlation With Local Aging
  - In a Specific Range
- Results Encouraging

Plant Test - Ringhals

- Tested 6 Circuits
  - 2 Anomalies
    - One Undocumented Splice
    - Other to be Assessed at Outage
- Tests Easy to Perform
- No EMI/RFI Problems
- No Termination Issues

Generic Letter 07-01

Wet Cables

Generic Letter 07-01

- NRC Letter Requires Utilities to Supply Failure Data on LV and MV Power Cables that are Inaccessible
- Condition Monitoring and Test Methods Used for Assessing Condition

Results

- 61 Units Have Had No Failures on Inaccessible MV Cables
- 47 Units no LV or MV Failures
- 14 LV Failures, but no MV
- Most Plants Had 3 or Less Failures
- 6 Had 5 or > and Replacing Cables
- MV Failures by Year Trending Upward to Less Than 5

Results Continued

- Age of MV Cables Not Showing As Significant Factor
- LV 62 Total (8 From One Duct)
  - 16 Damage, Cuts w/Water
  - 3 Brittleness and Cracking
  - 2 Moisture Intrusion – 1 Water
  - 1 Splice
  - 22 Low Megger
  - 17 Unknown

MV Tests

- Meggering – 72%
- Polarization Index – 31%
- Manhole Inspection – 39%
- Manhole Pumps/Dewatering – 31%
- DC Hipot – 14%
- Others – VLF Tan Delta, VLF Hi-Pot, Online Partial Discharge, PF, TDR, EMI

Summary

- GL 07-01 Results for MV Not Significantly Different From 2005 NEI Survey
- LV Shows Failures Not in Large #
  - NRC's Concern Level not Known
- Results Indicate Only a Few Plants Are Using Tests That Are Likely to Provide Useful Early Warning of Degradation

Fiber Optic Cable and Nuclear Plants

IEEE P1682

Fiber Optic Cable and Nuclear Plants

- Basic Information on Fiber Optic Cables, and Specific Information for Nuclear Applications
- Similar Information Presented at Previous ICC Meetings
- IEEE P1682 Meeting Tuesday 3:30 pm
  - D16W Qualification of Fiber Optic Cable

Class 1E LSZH Cable

Class 1E LSZH Cable

- Basic Information on Low Smoke Zero Halogen Cables and Some Specific Information For Nuclear
- Similar Information Presented at Fall 2007 ICC Educational Program

- D4D 2pm Today
  - Smoke, Toxicity & Corrosive By-Products of Cable Combustion

DG-1132 Update

IEEE 383 - Qualification of Safety Related Cables and Field Splices for Nuclear Power Plants

DG-1132 Update

- Qualification of Safety Related Cables and Field Splices for Nuclear Power Plants (IEEE 383)
- Draft Regulatory Guide to Replace RG 1.131
- Issued for Comments in June 2007
- IEEE, NUGEQ, Westinghouse, Exelon and Others Send in Comments

Issues

- Power Cables Routed Underground In Regard to Moisture or Flooding
- No Field Splices for MV Cable in Inaccessible Locations
- Condition Monitoring Programs
- Conductor Type in Definition of Representative Cable
- Connectors Included With Coaxial

Issues (Continued)

- Aged Cable With New Splice Kit
  - Combinations Could Imply Qualification as Sets of Cable and Splice
- Acceptance Criteria for Instrumentation Cable to Include IR and Signal Attenuation
- Miscellaneous Documentation

- D10D 10:15 AM Tuesday
  - Class 1E Cables (IEEE 383)

MV Cable Systems Training Course

For Nuclear Plants

MV Cable Systems Training Course

- EPRI Working with University of Wisconsin on MV Training
- Covers History, Basic Theory and Design, Material Properties, Manufacturing, PD, Standards, Installation, Ampacity, Splicing, and Testing

Medium Voltage Cable Testing

Medium Voltage Cable Testing

- Discussed Insulation Aging and PD
- AC/DC Hi-potential Testing
- Maintenance Testing
  - Online Partial Discharge
  - Loss Factor Measurement
    - Below 1 Hz May be Associated with Water and Thermal Degradation Byproducts

Rejuvenation of MV Cable

By Injection Process

Rejuvenation of MV Cable by Injection Process

- Reviewed Water Treeing Issue
- Review Method of Injecting Silicone Dielectric Fluid Into Cables
- 2 Case Studies Were Reviewed
  - 2006 May IEEE T&D – Case Study – Rejuvenation Fluid Injection Results From Duke Power's Little Rock Retail Tap Line, a 115 kV XLPE Buried Transmission Circuit

MV Cable Specifications

Proposal

MV Cable Specifications

- EPRI Proposed Project
- Common MV Cable Specification
  - Types of Replacement Cables
    - Compact
    - Waterproof – Water Absorbers/Blockers
  - New Plant Cables
  - Modern Standards
  - Production Tests to Assure Long Life

MV Failure Mechanism Assessment

Testing Update

MV Failure Mechanism Assessment

- Update of Testing on 3 MV Cables
  - 2 Samples Testing Did Not Look Good
  - 3rd Sample Looked to be in Good Condition
- Samples 24 to 33 Years Old
  - Visual Examination
    - Splitting and Swelling of Jacket – Sample 1
    - Corrosion of Metallic Shield – Sample 1
  - Decreased Insulation Resistance – 1 & 2
  - High Value of Dissipation Factor – 1 & 2
  - Water Trees – Suspected on 1 and on 2
- Sample 2 IR and DF was Acceptable Once Week Areas Removed

MV Cable Aging Management

And Testing Guide

MV Cable Aging Management and Testing Guide

- MV Longevity Source
- Practical Insights and Examples From Nuclear Plant Cable Problems
- Content
  - Testing, What to Test, Test vs Replace
  - Design Issues, Splices, Insulation, Installation, Surge Suppression
  - Failure Assessment
  - Replacement Cables – Water tight

Condition Monitoring

Of LV Cables

Condition Monitoring of LV Cables

- Some of This Information Presented at Fall 2007 ICC Educational Sessions
- Destructive Methods
  - Elongation at Break
- Nondestructive Methods
  - Indenter
  - Near Infrared (NIR) – Light Colors Only
    - Correlate Elongation and Plasticizer Content in PVC
    - Correlated By PVC Formula for Thermal Aging
      - Not Correlated as Well for Radiation
    - Work Being Done on EPR and XLPE
      - Effect on Cable Size
      - Combined Effects of Thermal and Radiation

QUESTIONS?