Underground HV Cable Research - Health Index for HV solid cables

Maxi Faridi
Innovation Engineer, UK Power Networks
maxi.faridi@ukpowernetworks.co.uk

Dawn O’Brien
Principal Consultant, EA Technology
dawn.o’brien@eatechnology.com
Agenda

• Background
• The Challenge
• Development of HV Underground Cable Prioritisation Model
• Methodology
• The Benefits and BaU implementation
• Q&A
Background

- Underground cables offer improved security of supply compared with overhead lines.
- Hence they represent a large part of asset base both in quantity and economic value.
- UK Power Networks operate more than 44,000 km of high voltage underground solid cables.
The Challenge

- Majority installed in 1960’s & 70’s in the UK
- A large portion of UG cables are nearing the end of their life
- Increase in trend of HV cable failures due to deterioration
- Replacements needed to maintain network reliability
- Wide-scale cable replacement is significantly expensive

Need for investment optimisation method to maintain network reliability in a more cost efficient way
Solution: HV Underground Cable Prioritisation Model

Objectives:

- Rank cable circuits according to their failure risk
- Understand HV solid cable deterioration mechanisms
- Develop a pro-active approach for cable replacement
- Quantify consequences of failure
- Optimise our investment strategy
- Improve network reliability by reducing number of faults

NIA Project Info:
Start Date: Sep 2015
End Date: Mar 2017
Funding: £932,477

Project Partners:
Project Stages

Phase 1:
- Identify causes of failure and cable degradation process
- Collection of cable samples following a condition driven fault for forensic analysis to understand the failure mechanism
- Develop an improved cable database to store all analysed results
Project Stages(2)

Phase 2:
• Identify contributing factors of cable degradation
• Identify sources of HV cable data for inclusion into degradation model
• Collation of asset data from database for analysis

Phase 3:
• Design and build HV underground cable prioritisation model

Phase 4:
• Implement the model into business as usual
Causes of cable failure

- Partial Discharge
- Sheath deterioration/corrosion
- Ageing/wear
- Moisture ingress

% of samples

© 2016. UK Power Networks. All rights reserved
Cable Sampling

- **Cable Analysis ID**
- **Details ID**
- **Date Analysed**
- **Cable Type**
- **Cable Visual Inspection** *(Outer & Inner Sheath / Armour / Lead Sheath / Metallic Screen / Conductor)*
- **Insulation** *(Waxing / Pin Holes / Creasing / Discoloration / Screen Interface / Manufacturing Defect / Carbon Deposits / Embrittlement / Water Tree / Electrical Tree / General Condition / Moisture Content / Tensile Strength / Crackle Test / Polymerisation Test / Elongation - median)*
- **Comments** *(Failure Mode / Comments)*
- **Post-Collection Images** *(up to 12 images)*
- **Summary** *(Health Index / Estimate Remaining Life / Recommendation)*
Cable Data

- Definition data from GIS system
- Fault data
- Feeder data
Partial Discharge
Health Index Model
CNAIM EHV Cables

- Age
  - Normal Expected Life
  - Expected Life
- Initial Health Score
- Health Score Modifier
- Measured Condition
- Reliability
- Forensic Analysis
- Observed Condition
- Measured Condition
- Partial Discharge
- Fault Rate
- Sheath Test
- Loading

© 2016. UK Power Networks. All rights reserved
Health Index Model
UK Power Networks HV Cables

- Environment
  - Normal Expected Life
  - Loading
  - Forensic Analysis
    - Partial Discharge
    - Fault Rate
- Age
- Expected Life
- Observed Condition
- Partial Discharge Fault Rate
- Measured Condition
- Health Score Modifier
- Reliability
- Initial Health Score
- Health Index

© 2016. UK Power Networks. All rights reserved
Health Index Model
UK Power Networks HV Cables

No. of customers
Sensitive Customers
Location
Cable Type

Network Performance Consequence
Safety Consequence
Financial Consequence

Criticality Index
## Outputs

<table>
<thead>
<tr>
<th>Health /Criticality</th>
<th>HI1</th>
<th>HI2</th>
<th>HI3</th>
<th>HI4</th>
<th>HI5</th>
</tr>
</thead>
<tbody>
<tr>
<td>CI1</td>
<td>2,146</td>
<td>3,745</td>
<td>4,331</td>
<td>998</td>
<td>274</td>
</tr>
<tr>
<td>CI2</td>
<td>4,656</td>
<td>5,521</td>
<td>5,998</td>
<td>1,342</td>
<td>347</td>
</tr>
<tr>
<td>CI3</td>
<td>2,244</td>
<td>3,381</td>
<td>1,594</td>
<td>1,166</td>
<td>442</td>
</tr>
<tr>
<td>CI4</td>
<td>1,976</td>
<td>1,071</td>
<td>2,994</td>
<td>240</td>
<td>0</td>
</tr>
</tbody>
</table>
Solution: HV Underground Cable Prioritisation Model

Existing Approach

- HV cable fault
- Fault repair
- Close incident

Pro-active Approach

- Identify high risk cables using HI tool
- Online field testing/fault locations
- Monitor to enable “just in time” response
- Preventive action taken
- Close incident
The Benefits

- Cable replacements are optimised with respect to cost and financial performance
- Improved security of supply and reliability of the network by knowing the condition of our UG cables better
- Reducing the number of customer interruptions
- Optimising our investment strategy replacing cables efficiently
- Best practice operational performance and optimisation
BaU Implementation:
To find out more- come and see us
Thank you