Integrated solution to target MV cable replacement

EDF R&D
EDF Energy
Agenda

- Background
- Previous works on cable life expectancy
- Cable Health Index
- Data flow and process presentation
- Case studies
- Conclusion
Background

Need for investment optimisation methods:

- Majority of cables installed in the 60’s & 70’s in the UK
- Some MV cables close to expected end of life
- Replacements needed to maintain network reliability
  ➔ Expected increase of investment level
Background

Several areas investigated for cable life expectancy prediction:

- Fault mechanisms
- Diagnostic methods
- Health Index design

Some of these techniques have been developed/tested within the EDF Group

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Fault mechanisms

Knowledge improvement on cable failure modes

- Cable and joints ageing tests in laboratory
- Network components (cable and joints) recovery
- Statistical analysis on fault reporting
Diagnosis techniques

**Offline diagnosis techniques**
- Tan delta
- Offline PD

**Online PD monitoring equipments**
General Health Index design

General design

\[ HI = \sum \left[ WF_i \times IF_i \right] \]

Weighting: relative importance of the influencing factor

Influencing factors: which are likely to influence link performances
(electrical stress, age, temperature, environment ...)

Grading: mark reflecting the link’s condition with respect to the influencing factor

First Application to 225 kV pipe-type cables

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New Health Index design

- Health Index based on failure mode probabilities
- 4 risks defined
  - Electrical risk
  - Thermal risk
  - Mechanical risk (incl. environmental risk)
  - Accessories risk
- Each risk modelled through a failure probability law (Weibull model)
- Diagnostics integrated – where available - as a risk level confirmation
- Relative weight of each risk assessed using:
  - In a first place Experts knowledge and experience,
  - Then from the failure statistics using Bayes’ approach.
Cable Health Index tool

- Risk-based approach
- Classification index based on
  - A probability of failure deriving from determinist criteria (cable type, operation condition, fault history, environment)
  - Failure impact on network reliability & economical aspect
  - Confirmation factors (On-site diagnosis)

Results

### Classification Index

<table>
<thead>
<tr>
<th>Classification Index</th>
<th>2008</th>
<th>2028</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of cable sections with low risk</td>
<td>270</td>
<td>270</td>
</tr>
<tr>
<td>Number of cable sections with medium risk</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Number of cable sections with high risk</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Number of cable sections with no conclusion</td>
<td>13</td>
<td>13</td>
</tr>
</tbody>
</table>

### Health Index

<table>
<thead>
<tr>
<th>Health Index</th>
<th>2008</th>
<th>2028</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of reliable cable sections</td>
<td>259</td>
<td>281</td>
</tr>
<tr>
<td>Number of cable sections that should be monitored</td>
<td>11</td>
<td>13</td>
</tr>
<tr>
<td>Number of critical cable sections</td>
<td></td>
<td>1</td>
</tr>
<tr>
<td>Number of cable sections with no conclusion</td>
<td>13</td>
<td>13</td>
</tr>
</tbody>
</table>

The overall accuracy of the loaded database is: **65.7%**
Process overview

**Web-based applications**
- Online PD Monitoring equipment
- Cable sample analysis database

**Information Systems**
- Control system
- Connectivity
- Fault reporting
- Load
- G.I.S.
- Asset database

**Cable Database**
- Cable description
- Load
- Fault history
- Cable environment
- Cable condition
- Impact of failure

**Cable Health Index Tool**
Classification Index computation
- Health Index
- Impact of failure or
- Condition monitoring (if high or medium risk level)
- Impact of failure

**Replacement & sample analysis**

**On-site diagnostic (if needed) & section selection**

**H.I. / C.I. Report**

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Case study

• Experimentation on a private network to validate the methodology
  – Health Index calculated for each section & classification into range from low to high risk
    • 6 sections, belonging to 3 circuits, classified as “medium risk”
    • Tan delta & offline PD confirmed risk on 1 circuit
  – 5-year investment plan reviewed using these outputs
  – Recommendations in terms of monitoring
Next steps

Similar experimentation being carried out in EDF Energy Networks (UK)…

- Objectives:
  - To demonstrate the accuracy of diagnostics and Health Index methods
  - To study how on-desk analysis (health index) supported by on-site diagnostic can lead to improved investment decisions

- Approach: comparison of classification given by fault history, diagnostic and health index

… bringing new challenges
Conclusion

• Issue of data quality and availability
  • Improvement of cable records: Field Management System & GIS

• Integration into IT systems: automation of data collection

• More case studies
  • To build confidence in cable health index efficiency: detailed gap analysis between effective state of recovered samples and the prediction
  • To implement fault rates and causes of failure processing to improve weighting factors figures
  • Trials and validation to be completed in France and the UK by the end of 2009
Any questions?