Underground Power Cable Health Indexing and Risk Management

Sander **MEIJER**, Peter **VAN DER WIELEN**, Mischa **VERMEER**, Jos **WETZER**, Evert **DE HAAN**; DNV GL, The Netherlands, sander.meijer@dnvgl.com, peter.vanderwielen@dnvgl.com, mischa.vermeer@dnvgl.com, jos.wetzer@dnvgl.com, evert.dehaan@dnvgl.com

ABSTRACT

Power cable systems represent a large part of a network asset base, both in quantity and economic value. Reliability on one hand and replacement on the other hand have to be balanced. In order to help the asset manager in prioritising his maintenance and replacement philosophy, DNV GL developed a health indexing tool to assess the cable system health and remaining life. Together with the risk management tool, it supports the asset manager in taking the appropriate decisions. The approach of both tools will be discussed and the theory behind the cable assessment functions will be described. Finally, one example of the outcomes of the health index is discussed.

KEYWORDS

Asset Management, Decision support system, Health Index, Risk Model.

INTRODUCTION

Network operators more and more are facing challenges in managing their grid effectively and in meeting a range of increasing stakeholder performance demands (safety, reliability, availability, and environmental and financial impact). Meanwhile, the underground power cables installed throughout the grids are continuously ageing, increasing the failure probability and associated risks. As a result, estimating the expected time to failure and timely taking mitigating measures becomes more relevant by the day.

Among the substantial amount and diversity of underground power cables found in modern electricity networks, each having its specific inherent ageing behaviour and failure impact, the asset manager's challenge is to decide which cable circuits require attention first and what actions need to be taken.

To give asset managers insight into the required long-term maintenance and replacement activities an advanced health indexing model for underground power cables has been developed and implemented [1].

Based on CIGRE Technical Brochure 358 [2] and in-house experience, a library of condition-assessment algorithms was developed. The health indexing model uses these algorithms to assess the asset remaining life (linked to probability of failure) and the time to additional maintenance. Through the use of Monte Carlo simulations the model is able to determine a certainty level of the assessment.

The model uses data from a variety of sources such as cable system specific data: age, ratings, loading data, short-circuit currents, failure data and condition data; and more general data: typical ageing trends and failure statistics. In case data is missing or inaccurate, deduction models and statistical inference are used to provide best estimates. The model provides clear overviews and visualizations for asset managers to help them oversee the health development of their overall asset base down to each individual cable circuit in detail.

Modern network operators use a risk-based asset evaluation to support decision making. Therefore, one needs to estimate the impact of a cable failure and prioritize all circuits on the basis of the resulting risk. Therefore, in an additional model, the determined health indices of the cable systems are being combined with selected business values, like safety, reliability, economy and environment, to end up with the overall risk per cable circuit. Related risk matrix plots visualize the various risk results. This all enables clear and structured overviews for asset managers to support appropriate actions at the right time.

HEALTH INDEX

The main task of a health index (HI) is to provide a dashboard of the assets' health, including a sense of urgency and a prioritization. For that purpose, the HI should present the results as clearly as possible and a simple colour scheme has been selected for that purpose.

Based on a Failure Mode and Effect Analysis, but also based on internal and external knowledge, specific Assessment Functions have been derived for power cable systems. From these analyses, the degradation mechanisms were determined, including the most relevant condition indicators.

The high level approach is shown in Figure 1. It can be broken down into the following items:

1. Input parameters
2. Transfer functions
3. Necessary attributes
4. Assessment functions
5. Assessment results
6. Folding functions
7. Health index

Input parameters

Input Parameters contain the data as inputted by the user of the Health Index model. The data is to be added on a per asset basis. The Input Parameters required for each asset are a combination of, amongst others,

1. Asset identification data (ID, serial number, substation, etc.)
2. Design data (make, model, rated voltage, current and power, specifications, etc.)
3. General data (year of commissioning, environmental aspects, etc.)
4. Utilization data (loading, temperature, etc.)
5. Maintenance and inspection data (PD, corrosion,