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HV SOLUTIONS

Recommendation For Advanced Asset Management of XLPE Transmission Power Cables

Background

Remaining Life Management of power cables deals with a complex issue, consisting of a combination of technical, strategic and economic factors. The process of natural ageing strongly depends on the operating mode of the cable system (nominal load or partial load, continuous or short time operation, overloads, number of starts, standstill periods).

The insulation degradation strongly depends on the service conditions such as: load, number and type of defects developed during years of service, repair quality and an environmental factor e.g. soil thermal resistivity, over-voltage conditions.

Aging failures indirectly are the result of cable service stresses. Four major cable stresses can be specified:

- Electrical stresses
- Thermal stresses
- Mechanical stresses
- Environmental stresses

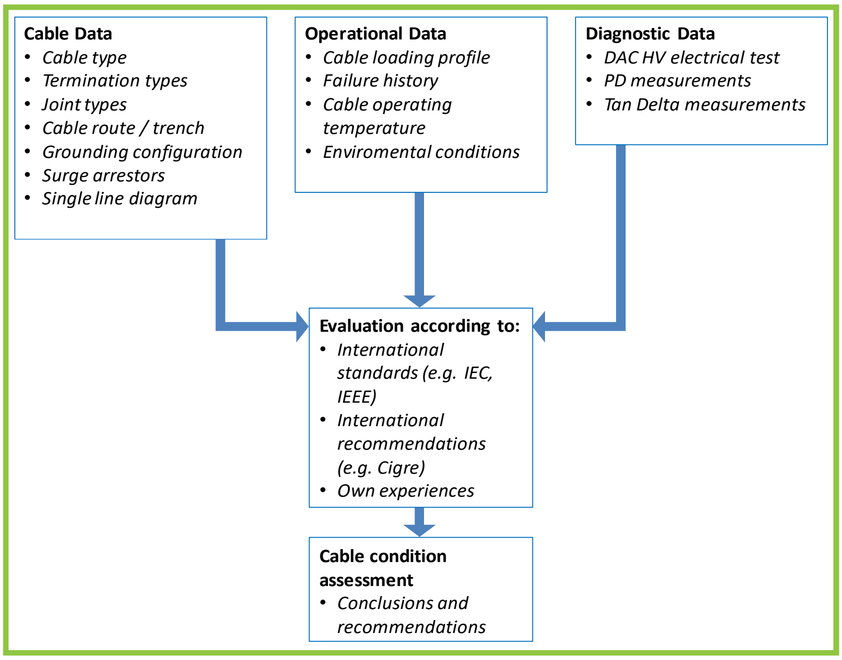
Breakdown traces on the field steering body of a 110 kV cable

Insulation Aging

Three types of degradations can describe degradation of cross-linked polyethylene:

- Chemical degradation of insulation and trapped charges
- Physical degradation (irreversible changes in dielectric structure)
- Electrical degradation (tracking, electric treeing)

Solid dielectric insulated cables are not affected by thermal ageing at normal operating maximum temperature, below 90 ºC. Gasification can occur when XLPE insulation is operated above 130 ºC, but it will not intrinsically affect the breakdown strength. The effects of the temperature are considered when operating XLPE insulation at high temperatures and are subjected to thermal cycling (thermo-mechanical stresses).



Cable condition assessment approach

Cable Condition Assessment Approach

To obtain the overall technical condition of the cable circuits and to evaluate the ageing factors for XLPE insulated cables (as far as detectable with electrical tests) the following diagnostic test will be performed and the results evaluated in relation to international guidelines:

- High voltage damped AC testing
- Partial discharge measurement with localization
- Dielectric losses by the dissipation factor (tan Delta)

Damped AC Insulation Condition Evaluation

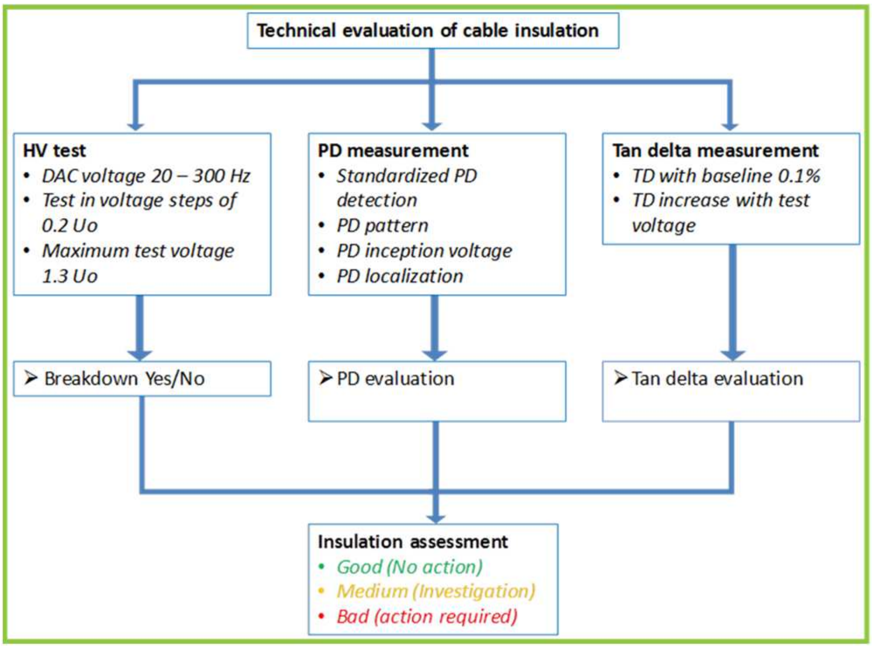
Damped AC (DAC) technology has the advantage of non-destructive testing and the method provides deterministic values of partial discharge (PD) activities in the cable system as well as the dissipation factor (tan Delta) of the overall cable system.

The overall cable condition evaluation is performed by:

- Condition Based Maintenance (CBM):
  - DAC HV tests and diagnosis and the evaluation of diagnostic parameters
- Cable condition index:
  - Partial discharge values and the PD evaluation together with the tan delta values (TD) are evaluated according to knowledge rules and statistical evaluation to obtain an overall condition index.
- Future Life Estimation (FLE):
  - Diagnosing the life consumption and future life estimation of Paper-oil insulated cable is based on thermal ageing and the diagnostic parameters (TD and PD).

Cable Condition Index

The measured tan delta values (TD) are used as input for statistical analysis to obtain TD boundary values for a particular type of cable insulation.



Damped AC cable insulation condition assessment

These boundary values can be used for cable condition indexing. To obtain these values the fitted statistical distribution of tan delta values from measurements on comparable cable types are evaluated . The boundary values are used to provide a condition index that is indicated with number and color:

- Index 9; very good (green)
- Index 8; good (light green)
- Index 6: moderate (yellow)
- Index 3: poor (orange)
- Index 1: very poor (red)

For each phase of a cable circuit at the different voltage levels the condition indexing can be obtained for the measured values. Eventually these values are combined to obtain an overall condition index per phase.

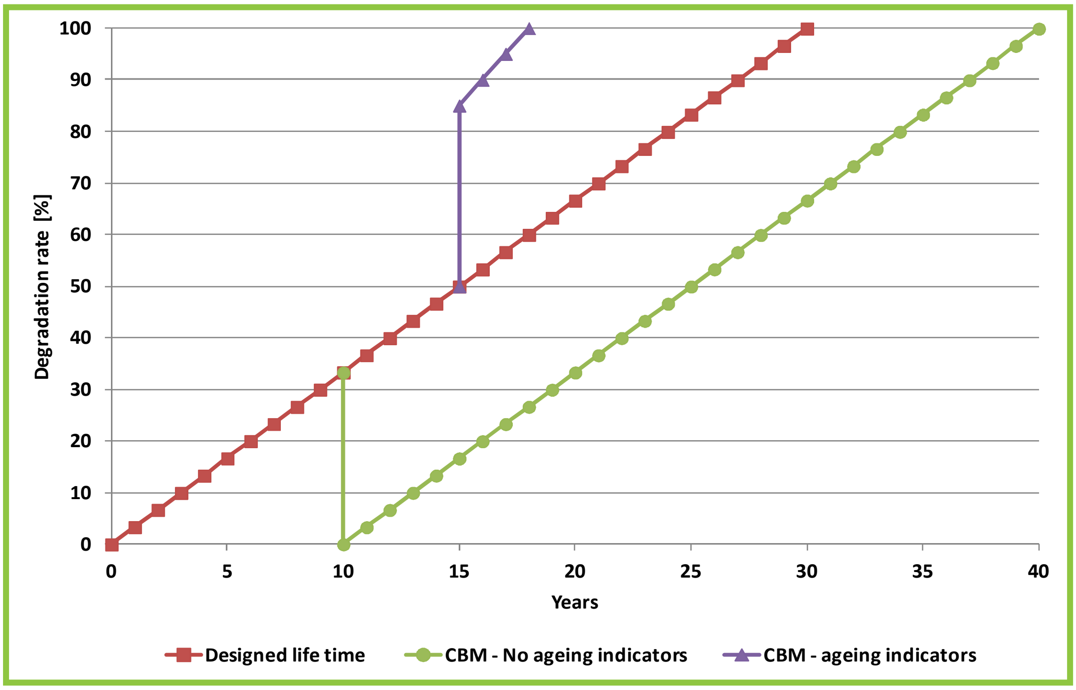
	Phase		
Condition parameter	**L1**	**L2**	**L3**
Concentrated PD	9	6	1
PDIV ≤ Uo	9	9	1
PD amplitude at PDIV	9	6	3
TD evaluation	8	8	8
Overall cable rating	**9**	8	**3**

Example of statistically obtained condition indices for the PD and TD evaluation for the condition indexing levels for a XLPE 220 kV cable

Future Life Estimation

As XLPE insulation is not sensitive to thermal ageing, as long as the maximum conductor temperature is not exceeded, this parameter does not play a role in the life consumption, which is the case with paper-oil insulation.

Mainly the ageing of XLPE insulation is more dependent on local defects in cable insulation or cable accessories that can be represented by partial discharges.



Example of future life estimation based on a technical lifetime of 30 years. At the moment CBM is performed, the FLE is adjusted based on the diagnostic parameters

Conclusion

- The application of damped AC technology with on-site diagnosis of transmission power cables provides the essential information to evaluate your cable condition.
- PD detection is an adequate method to get insight into discharging insulation defects in both XLPE and paper-oil insulated cable insulation.
- The diagnostic information as obtained using onsite DAC testing contributes in the overall cable condition assessment.
- The obtained experiences in the past years provided the information to develop our own specific knowledge rules to support maintenance and replacement activities of transmission power cables.

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