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FAILURE PREDICTION IN 50KV MASS-INSULATED POWER CABLE SYSTEMS

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ABSTRACT

Failure data together with the length and the ages of the 50 kV mass-insulated cables still in service are used as input for the statistical analysis. The choice of the appropriate distribution depends on the goodness of fit to the data. The fitted statistical distribution gives the relation of the number of expected failures per kilometre together with the age of the cable. To see what can be expected in the future the population in service together with the obtained failure rate curve is used. This gives statistical information regarding expected failures and critical connections. The analysis can help the asset manager to determine if immediate action has to be taken to meet the business policy e.g. condition assessment, maintenance or replacement.

KEYWORDS

Power cables, statistical failure analysis, Life time data

INTRODUCTION

Liberalization of the electricity market forces asset managers (AM) to choose for the most cost effective strategies on overhaul and replacement of network components. In particular, AM are interested to predict future failures and to determine the remaining life of the assets. Moreover, if failure data are available, statistical failure analysis can be a powerful tool to determine whether replacement is necessary, now or in the future to obtain a certain reliability of the network. For a particular part of the transmission network, in the past years electrical failures are reported in the 50 kV mass-insulated cable systems. This raises a concern about the number of failures to be expected in the future.

Up to now a total length of 56 km is still in service with an age distribution of 40 to 60 years. Reported failures are available over the past 8 years and have taken place in cables of different lengths and ages.

An important aspect in using this failure data together with the data of cables still in service is to take the length of the cables into consideration. The event of a cable failure has to be correlated with the length of the cable. After this the failure data together with the length and the ages of the cables still in service are used as input for the statistical analysis. The choice of the appropriate distribution depends on the goodness of fit to the data.

The influence of time has to be regarded for the discussion of ageing and wear-out processes corresponding to the specific trace of bathtub curve. Different maintenance strategies can be applied depending on the type of component and philosophy of the asset manager [1, 2]:

- Corrective maintenance (CM), which means the exploitation until failure and then repair.
- Time based maintenance (TBM), maintenance based on time based intervals or depending on the use frequency.
- Condition based maintenance (CBM), maintenance actions are performed based on the condition of the component obtained by e.g. measurements, inspection or on-site diagnostics [3, 4, 5].
- Reliability Centred Maintenance (RCM), maintenance based on safety, operational and economic criteria. It is a method by which operators can use failure data, system design redundancies and operating experiences to develop maintenance strategy.
- Risk Based Maintenance (RBM), the probability or likelihood and consequence of a failure results in the risk of a failure. The assessment of the likelihood and the consequence of a failure, resulting in a risk calculation provide a ranking system that can benefit in the choice for risk based maintenance or inspection programs.

For the last two maintenance strategies it is important to now the failure behaviour of a component and what the probability of failure and the failure rate is. For this purpose statistical analysis can be applied to life time data of components. Statistical statements can be generated whether the cables are in their end of life period regarding their age and with respect to the reliability requirements they have to fulfil according to the asset manager strategy. Besides this the statistical analysis can be used to see the development of expected failures in the future. The increase of failures in coming years can be shown together with the confidence bounds. The width of these confidence bounds are related to the amount of failures used for the analysis.

CABLE NETWORK

The mass cable

The cable network consisting of the mass insulated cables still in service has a total length of approximately 56 kilometres. Three phase cable are present, but the main used cable is single phase. In general a mass insulated cables contains a conductor (copper or aluminium) and several layers of paper impregnated with different types of oil, fillers, paper tapes, belt insulation, lead sheath and a PVC jacket, as shown in Figure 1. Mass cables are often used for medium voltage cable network but this type of cable is used for voltages up to 69 kV for three phases belted cables. In this case all cables are used in the 50 kV network. All cables under consideration have a service live longer than 40 years. This type of cable experiences