Abstract

In electrical power utilities, there is an ever-growing need for improved asset management. Power transformers are identified as one of the most critical and high impact items of plant within an electric network. For this reason, effective management of transformers is required to reduce the risk to power transfer due to unplanned outages, as well as the high consequential costs associated with catastrophic failure.

The objectives of this work include the evaluation of effectiveness of the current method implemented within Eskom, of evaluating transformers based on their condition/Health Index (HI) to develop replacement strategies, as well as identifying possible improvements to these methods and development of a model that can be utilized for determining the probability of failure of a power transformer based on its HI.

There are two components of the existing model for determining failure probability: the effects of age and HI. Historical failure data was collected for the period 1996 - 2014, including both severe and intermediate failures in the Eskom Transmission network. This included failure mode, demographic information, Dissolved Gas Analysis (DGA) results, oil quality test results and predicted Degree of Polymerization (DP). A data sample of healthy transformers was also collected. The failure data was fitted to a Weibull distribution, and the probability of failure based on age determined. This was compared to the existing distribution parameters and its effectiveness evaluated. Statistical analysis was carried out on the complete data set. Since there are multiple, continuous predictor variables and one dichotomous output variable, a multiple logistic regression model was fitted to the data. This was done for the existing HI, as well as for new HI parameters that were identified as the most significant in predicting the output.

The existing Weibull distribution was found to be ineffective in describing the existing failure data for ages <10 and >50 years. The average age predicted by this model is also unrealistically high and no practical evidence of this is found. An alternative Weibull distribution was found that better described the data. The logistic regression model fitted to the failure data using the existing HI parameters was found to be a poor predictor of probability of failure. An alternative model was found enabling a more accurate prediction, using fewer variables. Due to the large errors in measurements of the predictor variables and in some cases, exponential tolerances, as with DP, inaccuracies are expected within the model. The existing model is found to be ineffective in determining the probability of failure of a power transformer. New HI parameters, an age distribution and logistic regression model were determined, enabling a higher accuracy in predicting failure events and can therefore be utilized in various asset management initiatives and risk mitigation.