Asset management techniques for transformers
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ABSTRACT
In a deregulated/reformed environment, the electric utilities are under constant pressure for reducing operating costs, enhancing the reliability of transmission and distribution equipments, and improving quality of power and services to the customer. Moreover, the risk involved in running the system without proper attention to assets integrity in service is quite high. Additionally, the probability of losing any equipment vital to the transmission and distribution system, such as power and distribution transformers, is increasing especially with the aging of power system’s assets. Today the focus of operating the power system is changed and efforts are being directed to explore new approaches/techniques of monitoring, diagnosis, condition evaluation, maintenance, life assessment, and possibility of extending the life of existing assets. In this paper, a comprehensive illustration of the transformer asset management activities is presented. The importance of each activity together with the latest researches done in the area is highlighted.

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1. Introduction
Transformer asset management is generally considered to be one of the most important power system equipment asset managements. This is due to the substantial investments in the power transformers and the importance of the transformers as one of the major factors that affect the system reliability. The un-scheduled outages of the transformers due to unexpected failures are catastrophic in many cases.

Transformer asset management activities are numerous and researchers tackle them from different points of view. Maintenance plans and condition monitoring techniques are samples of the general asset management activities that can be applied to any equipment such as transformer, circuit breaker, high voltage capacitor, etc. However, each asset management activity is different from equipment to another. For example, condition monitoring techniques applied to transformers are different from those applied to circuit breakers or high voltage capacitors although some of these techniques may have some similarities. Also, one quantity can be tackled from different asset management points of view. For example, transformer hot spot temperature (HST) can be tackled from transformer condition monitoring point of view because it may represent an overloading or serious problem inside the transformer, and it can also be tackled from the end of life point of view because the higher the hot spot temperature over the normal value, the shorter the lifetime of the asset.

This paper focuses on the transformer asset management as one of the important power system assets. Fig. 1 shows the transformer main asset management activities. The transformer asset management can be classified into the following activities:

(1) Condition monitoring (CM) and condition assessment (CA) techniques.
(2) Performing maintenance plans.
(3) Aging, health, and end of life assessments.

In the following sections, each activity is discussed in detail.

2. Condition monitoring and condition assessment techniques
Transformer CM is concerned with the application and development of special purpose equipments/methods that are involved in monitoring a condition of a parameter in a transformer and its data acquisition while CA means the development of new techniques for analyzing this data to both predict the trends of the monitored transformer and evaluate its current performance. CM focuses mainly on the detection of incipient faults inside the transformer that are created from the gradual deterioration. Some of these incipient faults may be detected during routine maintenance; however, other faults may cause numerous problems before the routine maintenance cycle. As a result, the ability to have detailed information on the state-of-health of the transformer prior to carrying out maintenance work was unavailable. Also, the diagnosis

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