Priority Subjects with Limited Terms — **Further Improvement of Facility Operations and Maintenance Technologies**

Development of a Maintenance Scheme for Aged Power Transmission and Distribution Facilities

Background and Objective

Japan's electric power transmission and distribution facilities, which have been installed in large quantities during the high growth period and other specific periods, are aging. As such, their renewal is necessary in the near future. It is important to establish rational operation and maintenance techniques by considering cost effectiveness and to realize leveling of repairing and replacement.

In this research subject, sophisticated diagnostic technologies, which are necessary for this purpose, are developed, and asset management support tools (PC programs) considering their operational information and reliability are provided.

Main results

1 Development of diagnostic technology of oil-immersed power transformers

CRIEPI has been developing a diagnosis method for the abnormality of windings in oil-immersed power transformers such as deformation due to internal electromagnetic force based on Frequency Response Analysis (FRA). FRA had been applied to 64 oil-immersed power transformers, and transformers which have demonstrated abnormality were dismantled. Based on this investigation, diagnosis criteria in emergency situations and in routine inspections are proposed (Table 1). In emergency situations, such as invasion lightning surges, it is important to diagnose heavy deformation of winding and turn short. Diagnosis criteria are proposed and are applicable without past measured data. In detail diagnosis during routine inspection, slight displacement of winding due to aging of press board*1 can be diagnosed which cannot be diagnosed using the conventional method (Fig. 1) (H14010).

2 Development of diagnostic technology of oil-filled cable*2

Recently, it was reported that traces of partial discharges (PDs) were found in oil-impregnated insulation papers of oil-filled cables, although dissolved gases due to PDs were not detected by the dissolved gas analysis of insulation oil. So, it has been pointed out that the degradation of oil-filled cable can progress due to PDs in small voids near inner conductor, ultimately resulting in cable malfunction. In order to clarify the degradation progress of oil-filled cable due to PDs, PD characteristics from their inception to breakdown were investigated by using a cable insulation model. The insulation model has coaxial cylindrical structure which is close to that of oil-filled cable system, and its oil pressure was controlled by the oil pressure control system (Fig. 2a). As a result, PDs continued even when minimum allowable oil pressure was applied to the oil gap defect, and a breakdown occurred in the model after a certain amount of lead time from inception of PDs (Fig. 2b). This result suggests that we can detect the degradation progress by measuring PDs in the oil-filled cables in operation (H14011).

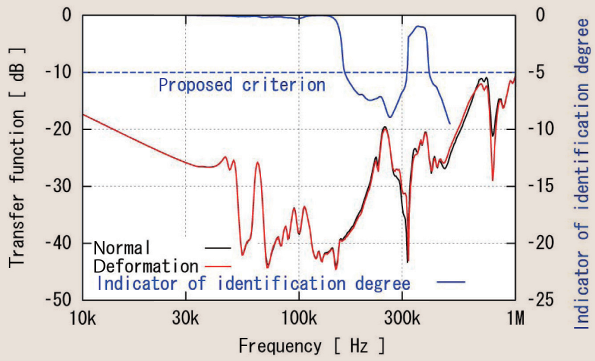
3 Development of asset management support programs and proposal of hierarchical asset management

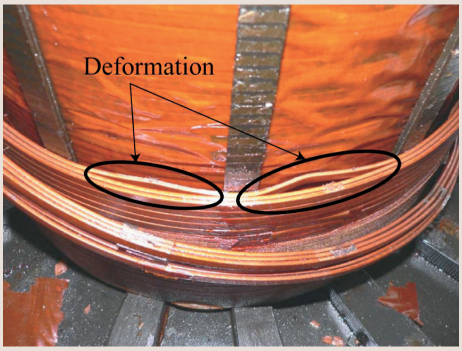
The asset management technique is being examined to rationalize maintenance strategies of electric power equipment. In Japan, high level reliability in electric power supply is expected, and low failure risk equipment has been operated with preventive maintenance. Therefore, not only statistical failure loss but also maintenance cost in normal operation should be evaluated. CRIEPI has defined an asset management support technique to assure accuracy of input data and objectiveness of the evaluation process in asset management, developed support programs for several kinds of equipment, and proposed the concept of hierarchical asset management, which can carry out evaluation corresponding to available data quality (H09). The asset management support technique is expected to be utilized for rational maintenance of aged equipment.

*1 Cellulose-based material constructed of several layers (plies) of paper compressed using a combination of heat and pressure.
*2 Cables that are electrically insulated by insulation papers and oil. Their oil pressure is kept higher than atmospheric pressure by feeding oil from outside to suppress the generation of voids and intrusion of air or moisture.

Table 1: Proposed criteria for diagnosis of abnormality of transformer winding

Situation	Targeted abnormality	Diagnosis method
Urgent diagnosis	Heavy deformation	Focus on difference of transfer function at 1kHz compared with that of other phases.
	Turn short	Focus on difference of lowest resonant frequency compared with that of other phases.
Detailed diagnosis	Slight deformation or displacement	Indicator of identification degree of transfer function is compared with a threshold.

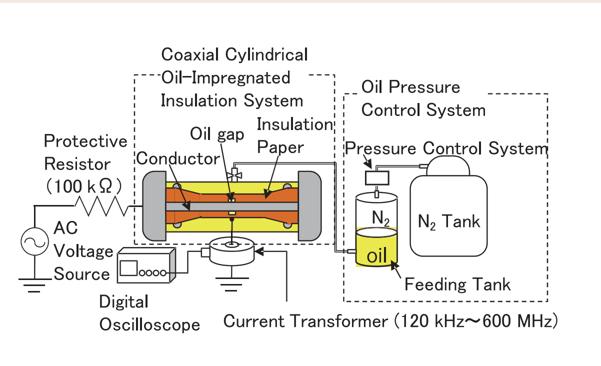


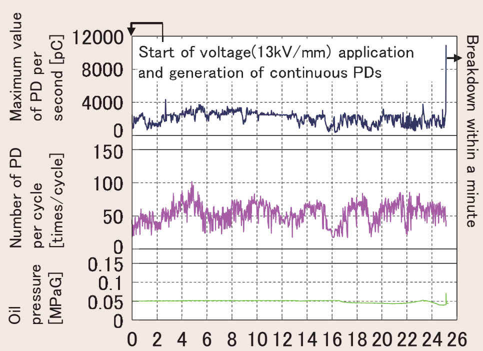


(a) Deformed winding and indicator of their identification degree (b) Transfer functions of power transformer

Fig. 1: Example of diagnosis of transformer whose winding is forcibly deformed

In FRA., winding abnormality is detected by detecting change of transfer function compared with that measured when the transformer was normal. An indicator of identification degree of two transfer functions and diagnosis criteriion of abnormality of winding using the indicator are proposed.





(a) Coaxial cylindrical oil-impregnated insulation model and experimental equipment

(b) Transition of partial discharge characteristics from inception of continuous PDs to breakdown

Fig. 2: Overview of PD measurement of oil-impregnated insulation mode

PDs occurred at oil pressure higher than atmospheric pressure and at the assumed oil gap of coaxial cylindrical electrodes which were insulated by insulation papers and oil as shown in (a). PDs were measured by a high frequency current transformer and a digital oscilloscope. As shown in (b), a large number of PDs continued and finally a breakdown occurred. Also, a large number of PDs with larger charge magnitude occurred and continued for some time before breakdown. This change in PD characteristics may be indicative of breakdown.