Recent Maintenance Activities

Masao Sakurai,
Yutaka Motoi

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Abstract

In order to manage electrical facilities in proper order, maintenance is indispensable. The owner of an electrical facility (for private use) is required to establish and observe the internal safety regulations in line with Article 42 of the Electric Utility Industry Law. Namely, the owner of an electrical facility must draft a maintenance program and execute it accordingly. In the past, maintenance was considered to be a kind of corrective measure or a work to repair the faulty devices. Since then, the idea of maintenance as a preventive measure was conceived. Preventive maintenance has changed from a Time-Based Maintenance (TBM) to a Condition-Based Maintenance (CBM).

1 Preface

In order to prevent failures and assure stable operation of facilities, it is essential to perform maintenance by an experienced engineer who has an abundance of knowledge and expertise regarding equipment. For a recycling society, we offer various maintenance services to cover all the lifecycles of equipment. From the commencement of facility operation until the period of aging and renovation, preventive maintenance is indispensable to keep facilities in their best condition. Fig. 1 shows the lifecycle of an electrical facility.

This paper introduces our new preventive method form (new maintenance) based on Time-Based Maintenance (TBM) incorporating the concept of Condition-Based Maintenance (CBM) method.

2 Our Initiatives

In our new maintenance service program, we use a maintenance method to make a live-line diagnosis first to grasp the state of electrical facilities before the periodic inspection (involving the facility shutdown or power outage).

The techniques of live-line diagnosis involve various approaches. Some typical examples are shown in Figs. 2 ~ 4. When live-line diagnosis is introduced, the following three effects can be expected:

(1) Early discovery of any symptom and presence of abnormality in facilities
(2) Efficient maintenance implementation
(3) Accurate assessment of facility conditions

In order to improve the diagnostic accuracy further, we are promoting the development of new diagnostic tools at the time of performing a close inspection of diagnostic contents, data analyzing method, verification test, and confirmation of the capability of our new tools.

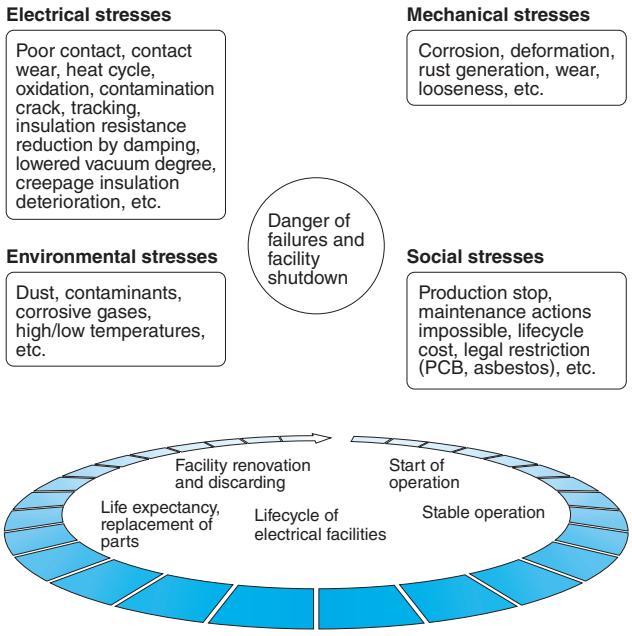


Fig. 1 Lifecycle of Electrical Facilities

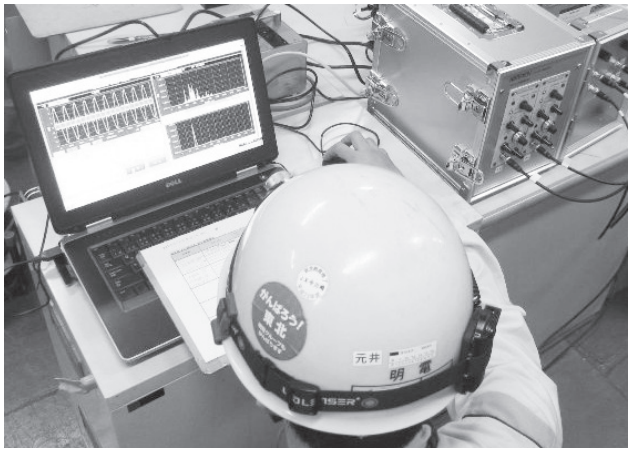
From the start of operation to system renewal, facilities undergo a variety of stresses as shown.

Fig. 2 Situation of Thermographic Diagnosis

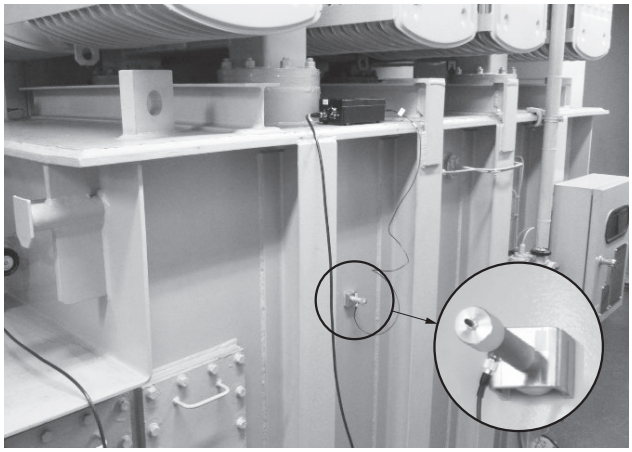
It is possible to check the state of abnormal overheating by taking a picture of the thermal distribution in equipment.

Fig. 3 Analysis of Insulation Oil

By insulation oil analysis for an oil-immersed transformer, it is possible to know the amount of components in oil and also determine the state of interior and the degree of deterioration.



(a) Partial discharge indicator by ultrasonic detection method



(b) Oil-immersed transformer sensor installation

Fig. 4 Partial Discharge Diagnosis

It is possible to examine partial discharges generated from the insulation materials of high-voltage equipment.

3 Grasp of Situation and Effect

3.1 Situation of Electrical Facilities

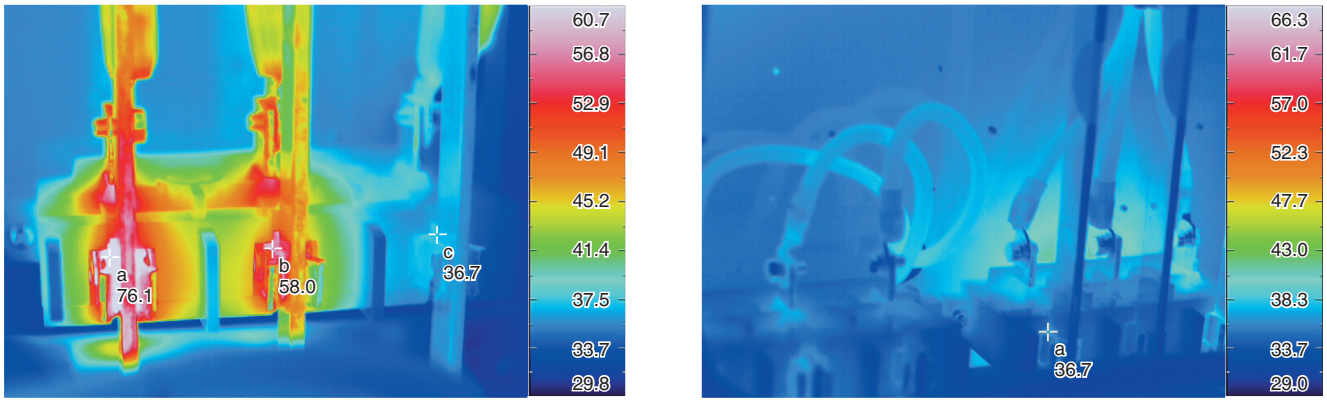
The method of assessing the state of an electrical facility by a new maintenance method and the results are described below. It is sometimes difficult to fully comprehend the potential risk of a situation of an electrical facility at the time of periodic inspection (involving facility shutdown or power outage). It is almost impossible to discover any symptom of abnormal phenomena such as abnormal overheating, partial discharge, etc., occurring in the middle of system operation.

3.2 Method of Assessing the State of Electrical Facilities

As a method of assessing the situation during operation, major diagnostic approaches are shown below.

(1) Measurement of partial discharge

Transformers, circuit-breakers, and rotating machines are the major equipment in electrical facilities. These machines can often suffer from inner discharges due to the formation of voids and/or gaps in insulation※1 and surface discharges caused by deposits of dust and contaminants on the insulation surface. If such a discharge-related phenomenon occurs, ultrasonic waves are generated and physical and chemical phenomena follow. Since partial



(a) Checked by live-line diagnosis (Temperature: 76.1℃)

(b) After treatments for improvement (36.7℃)

Fig. 5 Example of Thermographic Diagnosis

(1) Abnormal spots in objective equipment: Local heating in main-circuit connectors of the control center
(2) Cause: Spring pressure of the contact mechanism is lowered due to secular variations and contact resistance is increased.
(3) Countermeasures: Replacement of connectors at the time of periodic inspection

discharges (including corona) generate a strong signal in the vicinity of 40～60kHz in the frequency band, a method of detection in terms of ultrasonic waves is suitable for use. We perform field diagnosis by using a partial discharge indicator with an Acoustic Emission (AE) sensor.

(2) Measurement by thermography

Any object matter radiates energy (infrared rays or electromagnetic waves) at a specific wavelength because of vibration or rotation of its atoms and molecules so long as its temperature is above absolute zero (0K: −273.15℃). Utilizing this principle, an infrared radiation thermometer is used to measure heat generated from electrical facilities during operation. With this instrument, we can check the occurrence of thermal deterioration and abnormal phenomena. **Fig. 5** shows an example of thermographic diagnosis. If such a thermographic measuring instrument is used, the status of equipment can be made visible and it is possible to locate the abnormal section in terms of temperatures, or recover after any remedial measures have been taken.

(3) Analysis

For the enclosed type of equipment where insulation oil or SF_6 gas is used as an insulation medium, sampling of such an insulation medium is carried out. It is then possible to grasp the internal conditions by analyzing the type and quantity of generated gases contained in the insulation medium.

(4) Evaluation of the rate of aging in electrical facilities

This is an approach to digitize the conditions of facility deterioration for the respective equipment units and facilities for the purpose of a numerical evaluation based on the evaluation table. Numerical evaluation makes it possible to define ranking of deterioration conditions among the same equipment units or in comparison with other facilities. Sequence planning for renovation or measures against aging deterioration can be made easily.

(5) Insulation diagnosis※1

Insulation performance can be checked for high-voltage equipment by making insulation diagnosis (DC absorption test, tanδ test, AC current test, partial discharge test). As a result, the status of insulation deterioration can be identified. Making comparisons with our accumulated data, it is also possible to determine residual life expectancy※2 by computation.

We have dedicated vehicles (insulation diagnostic cars) equipped with a set of measuring instruments, and these cars are allocated to major business bases throughout the country; therefore, insulation diagnosis can be carried out easily on-site. As a result, diagnostic work and data collection time can be curtailed, and this can reduce the amount of shutdown time at the customer's facility. Since the length of the test cable loaded on the diagnostic car is 100 meters, measurements can be carried out even from a distance. **Fig. 6** shows an external appearance of the insulation diagnostic car and meter installations inside the car.

3.3 Effect

Early discovery of any symptom of abnormali-

(a) External appearance

(b) Meter installations inside the car

Fig. 6 **Insulation Diagnostic Car**

An external appearance and meter installations inside the car are shown.

ties can lead to favorable actions for repair (repair parts ordering, work plan) based on the periodic inspection (facility shutdown). Thanks to the use of approaches by such a new maintenance method, a facility's status can be assessed with higher accuracy. As a result, repair points can be defined and limited maintenance time (facility shutdown time) can be performed effectively. This leads to a decrease of sudden failure occurrences.

4 Postscript

This paper introduced our maintenance initiative for electrical facilities. Since new maintenance method has been adopted, various conditions of electrical facilities can be observed from various angles and grasped accurately. Consequently, we can reduce the occurrence rate of sudden failures.

In order to further reinforce the lifecycle engineering for customer facilities, we have to offer more effective new maintenance services. For this purpose, our challenges are to increase technical menus for diagnosis and to realize higher accuracy.

Going forward, we will offer newer approaches of the diagnostic techniques and would like to offer maintenance services to meet the needs of our customers.

Notes: ※1. Not applicable during charging (Facility shutdown is required.)

※2. Presently possible only for rotating machines.