Maintenance and Lifecycle Engineering

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Abstract

Most electrical facilities and those installed to support social infrastructures are required to have stable reliability while it shall also consistently be economical and without causing social anxiety. The same thing can be said for vital facilities for general industries like factories, plants, etc. The key factors in realizing such a goal are proper maintenance and its supporting technologies.

"Engineering" denotes a branch of technology and is also synonymous with technics – an art of a process. In the latter sense, this word encompasses activities which aim to produce the best practice of facility maintenance and management. The purpose of lifecycle engineering is to maintain whole facilities under the best working conditions throughout its in-service period, while evaluating overall facilities in a comprehensive manner. In other words, this indicates the condition in which economics meet reliability and both are working sufficiently. It is also necessary to apply versatile technologies relating to major elements of the facilities (apparatus and equipment) and ancillary materials (cables, pipes, etc.), and apply scientific knowledge to enable comprehensive evaluation.

Recently, there are many instances of damages due to large-scale natural disasters. These disasters in no small way affected society's overall way of thinking. It calls for new operational systems and judging criteria with due consideration of not only ordinary failure risks but also on risks stemming from disasters.

1 Preface

From the latter half of the high economic growth period in Japan to the collapse of bubble economy in the 1990s, many electrical facilities were introduced and installed. Most of these facilities are presently in the aging stage and the probability of an occurrence of system failure constantly increases year after year. Formerly, replacement of faulty parts and Time-Based Maintenance (TBM) were widely prevalent according to years of usage and actual working time. Recently, however, a maintenance approach by the name of Condition-Based Maintenance (CBM) has been replacing the former method. The new approach is gradually becoming popular as a more rational method.

We conduct proper and timely deterioration level diagnoses for existing equipment and facilities in addition to conventional inspection and maintenance or TBM-type maintenance. Our effective CBM activities including subsequent necessary treatments are called "New Maintenance" and we are actively promoting it. In addition, total evaluations are carried out for the facilities. Further, we are promoting technical developments oriented toward the Risk-Based Maintenance (RBM) which focuses on the most imminent risks and is considered as a method to seek effective and economic treatment options.

This paper introduces the outline of our maintenance technologies and our activities in terms of lifecycle engineering.

2 Outline of Meiden Maintenance Technologies

2.1 From Operation Start Period to Stabilized Operational Period

The overview of the lifecycle stages for electrical facilities including power receiving substations is

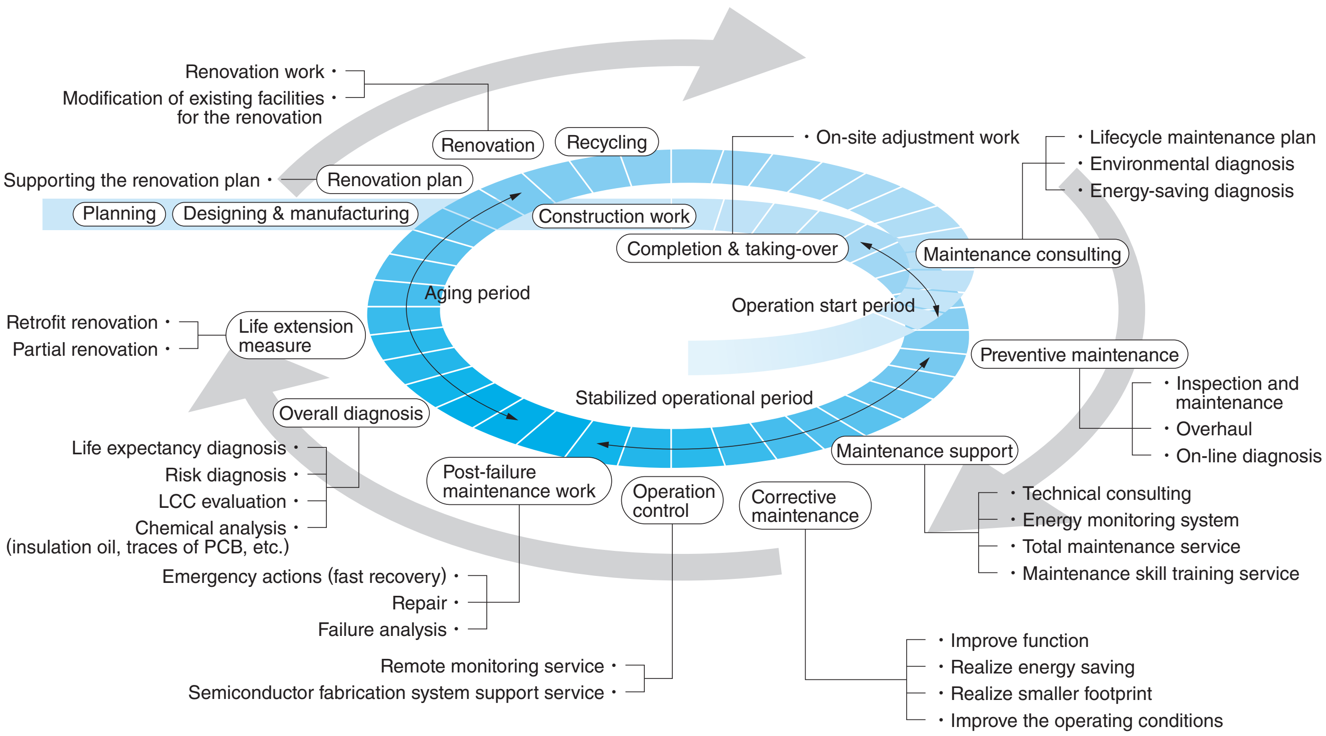

Fig. 1 **Lifecycle Engineering for Electrical Facilities**

At each stage of the lifecycle from facility planning and installation to retirement and renovation, the roles of maintenance are shown in the diagram.

expressed in a flow diagram as shown in Fig. 1. At each stage, we are promoting its activities for maintenance and maintenance supporting business, making full use of its expertise as a supplier of power products.

During the period from the operation start period to the stabilized operational period, we draw up a medium- and long-term lifecycle maintenance plan so that the environmental diagnosis and/or energy-saving diagnosis can be carried out by focusing on preventive maintenance. Throughout these activities, we are evolving our overall maintenance supporting business.

2.2 Stabilized Operational Period to Aging Period

In the period from the stabilized operational period to the aging period, we conduct corrective maintenance including functional upgrades. Further, we actively promote facility diagnostic service mainly for parts and units under high-level deterioration.

Diagnosis is categorized into abnormality diagnosis and residual life diagnosis. In either case, the primary factor of failure is mostly due to direct and indirect aged deterioration. In particular, residual life diagnosis is a technology to estimate the remaining operational life by quantifying the deterioration progress degree (annual rate). This technology requires many know-hows and a rich database exceeding the normal requirement level of maintenance technologies.

2.3 Aging Period to Product Life Extension and Renovation

Generally speaking, after-failure maintenance (measures taken after the occurrence of failure) tends to increase at the aging period of facilities. For any failure that has happened unexpectedly, chemical analysis as well as appropriate failure analysis will be carried out so that we can make improvements and take product life extension measures based on the diagnostic results. According to the result of the diagnosis for our supplied facilities and equipment, and considering the conditions of operational environment, life expectancy diagnosis and risk diagnosis will be carried out. We propose to our customer that they take proper measures such as partial renovation, retrofit upgrading, and improvements, or draw up and implement proper treatment for overall renovation of the facilities.

3 Contribution to Lifecycle Engineering

As described earlier, the major purpose of lifecycle engineering is to realize effective cost management as a whole, while minimizing the failure risk less than a certain level during the life of the in-service period of the facilities. For this purpose, regarding damage from general failures and partial functional insufficiency and also from large-scale failures, these should be reflected in the risk cost to make a well-balanced evaluation. We conduct an overall diagnosis or evaluation based on the results of a risk analysis which shows the expected failure rate output according to the risk diagnosis and risk cost evaluation. **Fig. 2** shows a series of such procedures.

Our technologies of maintenance, diagnosis, and improvements presently available are effectively functioning as a means of realizing optimization of each respective unit, equipment, and component. When such element-based technologies are put together to effectively be applied to the maintenance service on the basis of comprehensive evaluation and judgment criteria, it will pave a way for overall system improvement, from the partial to spot-level improvements. This approach will result in the reduction of total cost (lifecycle cost).

This approach can be regarded as a rational method to abate over-maintenance (excessive maintenance) which often arises as a result of fear of failure risk. This is also called maintenance coordination or reliability coordination. An approach for risk-based management or RBM concept is considered a practical method.

For the life expectancy diagnosis of major equipment, medium- and long-term failure and deterioration trend management is effective. In addition, application of multivariate statistics such as principal component analysis and neural network is useful. It is a statistical analysis approach for diagnosis.

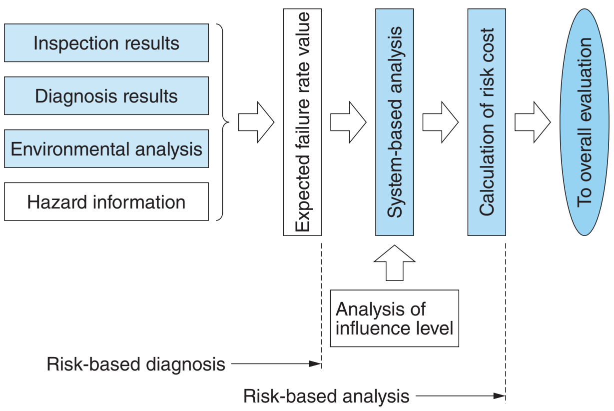

Fig. 2 Overall Evaluation from Risk Diagnosis and Analysis

A workflow shows how each result adds up to the final overall evaluation. This approach is in line with the risk-based management concept.

As mentioned above, real lifecycle engineering is intended to realize the effective risk and cost control through the data-based overview of entire facilities. It should be based on the probability predictions of all possible failure occurrences until the next expected date of the system renovation. Lifecycle engineering is made possible through full use of various proficiencies in terms of overall diagnosis and evaluation.

4 Future Business Development

For a general statistical analysis, the data accumulation of a huge volume of diagnostic data and failure-related data is a prerequisite. In regard to residual life prediction or insulation breakdown voltage value from the diagnostic results, its accuracy and reliability of result output can be raised to a practical level only if rich sample data is available. In most cases, however, we often have to confront the issue of poor records of insulation breakdown voltage values and failures (hazard data). When the prediction values such as residual life are obtained from insufficient data in terms of quality and quantity, their accuracy index or a coefficient of determination (correlation coefficient) is low and it may not make a convincing case.

We developed and utilized a facility information management system (e-FaIn) to be introduced later in this issue. We are currently continuing to accumulate real field data including hazard data necessary for improvement and advancement of our diagnostic technologies. We are also promoting the study and introduction of a new approach without sticking simply to statistical analysis-based treatments. Such a new approach should be more practical and reasonable. We are also researching the application of the Bayes' theorem that will raise the accuracy of final evaluations (posterior probability) based on the constant reflection of past results of inspection, diagnosis, and analysis. Such evaluation is based on a certain level of rational judging criteria (like prior probability) such as evaluation of aged deterioration and operating conditions. We view it as an evaluation approach that can effectively reflect our industrial knowledge as a supplier and maintenance experiences accumulated so far. We are planning to apply this evaluation method to an actual servicing case in a limited scale in Fiscal 2013.

5 Postscript

Nowadays, the risks of large-scale natural disasters have become a significant element of concern that cannot be ignored. Our recent major disaster-relief activities are discussed in other articles in this issue. As a supplier of power products and an expert on maintenance, it is our challenge to incorporate the natural disaster risks in the lifecycle engineering for the facilities.

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