Introduction of Analytical Technologies at the Materials and Environmental Performance Analysis Center

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Abstract

We are promoting to improve our manufacturing excellence with highest quality as the most important standard for our products, systems, and maintenance services. Thus, we offer with highly reliable products and services to our customers.

The Materials and Environmental Performance Analysis Center (MEPAC) is a new analysis-based laboratory established in 2010 and has been operating. This organization promotes "the improvement of product quality," "the creation of new innovative products," and "an environmentally conscious design" by drawing on its updated facilities, analysis, and evaluation technology. Since MEPAC deals with the environmental performance of Meiden Group products, it involves all stages from the early development to various Business Units (BUs) relating to analysis work with product development. In order to contribute to the improvement of product quality in terms of materials, MEPAC staff is constantly aiming to improve its analytical skills and techniques.

During our lengthy accumulation of technical resources such as analysis and testing techniques, the staff is taking valuable information from the testing samples so that information can be provided in a timely manner to the related BUs.

1 Preface

Our products cover a wide range of equipment and units such as generators, substation equipment, electronic machines, IT devices, and many others. These products use many kinds of parts and materials. If any product failure occurs on the market, we will incur substantial financial damage as a result of replacing and fixing the failed parts, and in addition to losing the trust from the customer. As such, we are promoting to improve manufacturing excellence with the highest quality as our most important management standard.

Our products are designed and manufactured with the expectation that proper maintenance will be provided, resulting in maintaining good product quality by the implementation of such proper maintenance.

As shown in Fig. 1, Meiden Materials and Environmental Performance Analysis Center (MEPAC) are promoting three key action topics in analysis and evaluation technologies: "improvement of product

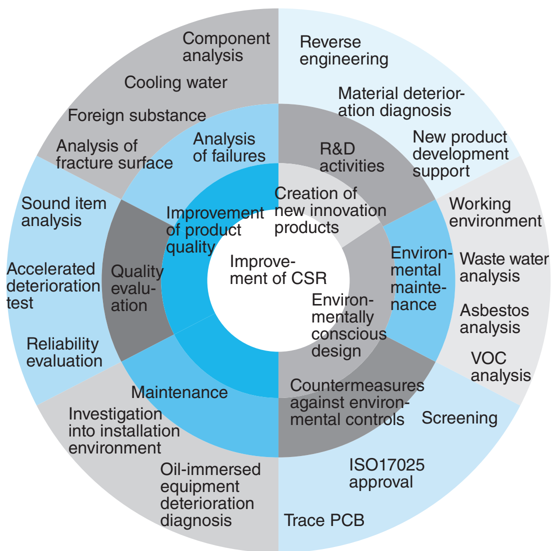


Fig. 1 Three Essential Execution Items

MEPAC is promoting the three key action items: "improvement of product quality," "creation of new innovative products," and an "environmentally conscious design."

quality, "creation of new innovative products," and an "environmentally conscious design." Electrical facilities installed in the field are subject to deterioration due to years of operation and the conditions during installation. In regard to "the improvement of product quality," we take proactive prevention measures against any future occurrence of defects and failures. We do this by inspecting the facilities and system components in order to find possible deterioration and erosion and determine the degree of damage with analysis and diagnosis. Fig. 2 shows the maintenance services offered by MEPAC.

This paper introduces the analytical technologies possessed by MEPAC that gives basic supports to Meiden's maintenance services.

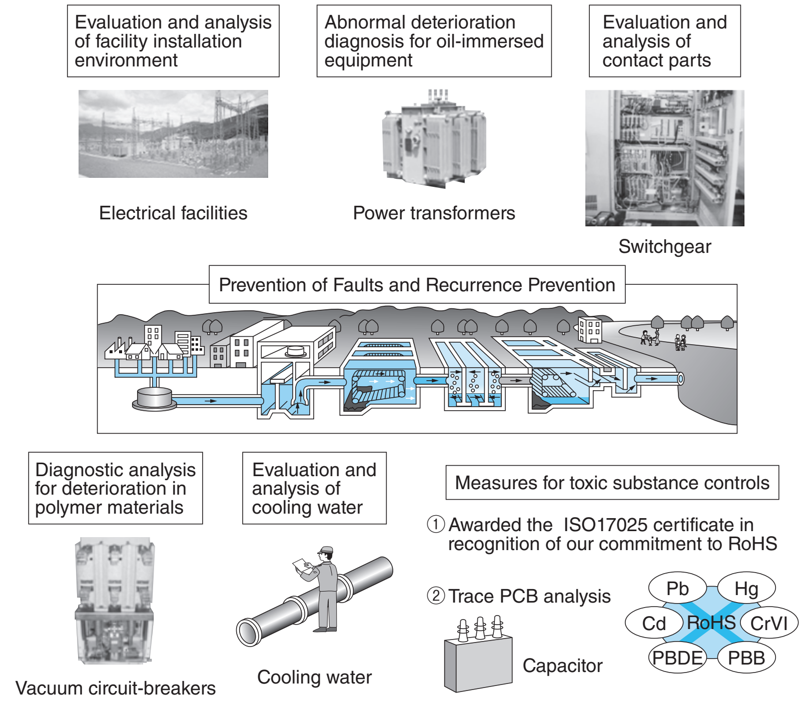


Fig. 2 Maintenance Services at MEPAC

MEPAC is promoting a variety of maintenance services such as an evaluation of facility installation environment and abnormal deterioration diagnosis for oil-immersed equipment.

2 Technology of Maintenance Services

2.1 Facility Environment Evaluation Technology

In environmental conditions for equipment installation, the presence of corrosive gases is a factor which compromises the reliability of products. According to some examples of analysis related to deficiencies occurring in our products, many cases of faults result from corrosive gases. In order to assure quality of our products, MEPAC uses technologies to evaluate the effect of corrosive gases that possibly occurred at the installation sites. The evaluation approach comes in the degree of contamination measuring method, the short-term evaluation method by direct gas sampling, the monitoring method with the use of metallic test pieces according to the type of corrosive gas, and the long-term evaluation method through continuous measurement of gases. The optimal effective method is selected according to the environment of each product installation and operating conditions.

As suggested above, overall evaluation is periodically carried out under the working conditions before and after the installation of equipment through the combination of short-term and long-term measurements so that the occurrence of faults due to corrosion can be prevented. Fig. 3 shows the installation environment evaluation system.

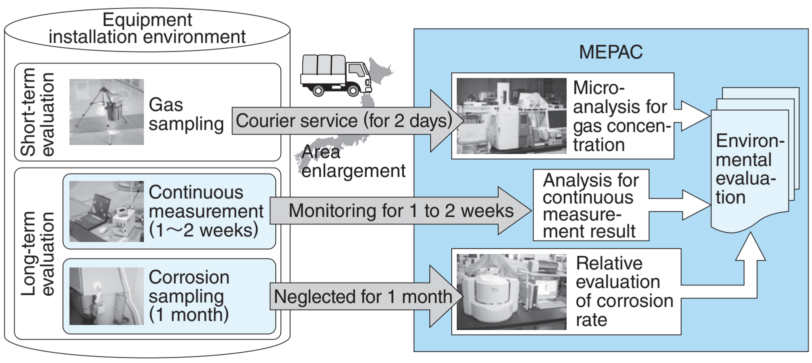


Fig. 3 Installation Environment Evaluation System

In combination of short-term and long-term evaluation of corrosive gases, overall evaluation is carried out to control the equipment installation environment.

2.2 Cooling Water Evaluation Technology

According to years of operation and the installation environment, cooling water pipes begin to deteriorate due to corrosion and accumulation of sludge. Corrosion developed inside pipes is one of many defect-causing factors. The degree of corrosion in the pipe material is quantitatively evaluated by component analysis and/or elementary analysis. **Fig. 4** shows a cross-section of a corroded cooling pipe.

Ion components contained in cooling water are analyzed and the coefficient of saturation is calculated to evaluate corrosiveness of water or how easily it accumulates sludge. **Fig. 5** shows the ion chromatography analytical equipment.

2.3 Expected Residual Life Diagnosis for Oil-Immersed Power Transformers

The operational life of an oil-immersed power transformer depends on the degree of deterioration of insulation paper (mechanical strength) around the transformer coils. Rate of deterioration varies greatly by the period of use, machine type, and operating conditions (operation, load, oil temperature, etc.). As deterioration in insulation paper increases, the insulation paper's mechanical strength is reduced and various deterioration-related sub-products (furfural, carbon monoxide, carbon dioxide, etc.) are increasingly generated. **Fig. 6** shows a scene of furfural analysis. At MEPAC, components of furfural and gases such as carbon monoxide, and carbon dioxide are quantitatively analyzed to estimate the degree of secular variation in insulation paper. According to the relationship between mean polymerization degree and life of insulation paper (see **Fig. 7**), analytical

Fig. 4 **Cross-Section of a Cooling Pipe Suffering from Corrosion**

A view of corroded cooling pipe is shown after cutting. Corrosion started at a welded section in the pipe and developed into water leakage.

Fig. 5 **Ion Chromatography Analytical Equipment**

Ion chromatography equipment is used to analyze the ion concentration in cooling water containing a corrosive substance.

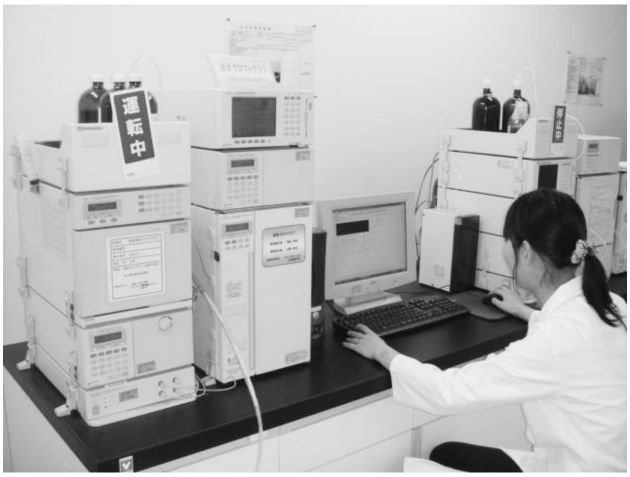


Fig. 6 **Furfural Analysis**

A view of using a high-speed liquid chromatography analyzer is shown; a unit intended to analyze the furfural in oil (chemical substance generated as a result of deterioration decomposition in the insulation paper).

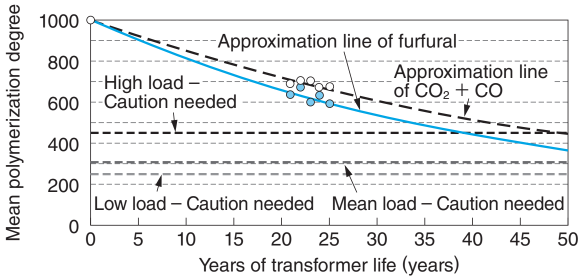


Fig. 7 **Relationship between Polymerization Degree and Service Life**

Deterioration diagnosis for oil-immersed power transformers is performed to predict a transformer's service life through the calculation of mean polymerization degree of insulation paper based on the measured value of deterioration product furfural in insulation oil sampled from the specimen transformer and that of $CO_2 + CO$.

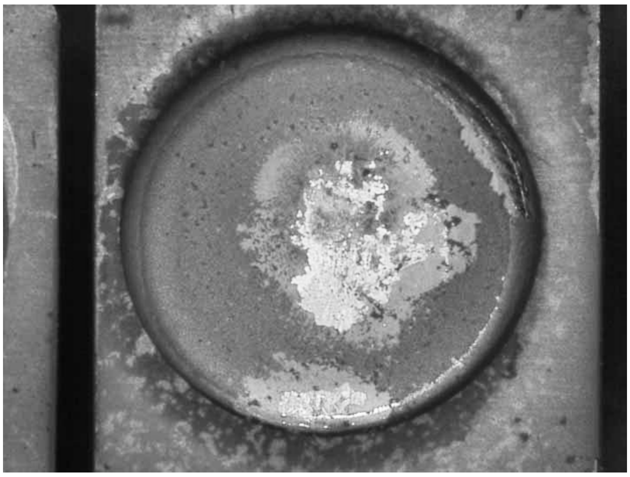


Fig. 8 Corroded Relay Contact

A view of relay contact is shown, the surface of which is corroded under corrosion developing circumstances.

Fig. 9 Electronic Microscope with Analyzer

A view of measurement is shown with an electronic microscope provided with the functions of elementary analysis and distribution analysis.

services are offered through expected residual life diagnosis for transformers.

2.4 Contact Parts Evaluation Technologies

Under circumstances of installations such as water treatment plants where presence of corrosive gases is anticipated, some cases have been reported regarding the deteriorating corrosion of the relay contacts in products and also at contact points of switches, connectors, etc. Fig. 8 shows a corroded relay contact. In order to prevent the occurrence of failure due to corrosion in contact points, our Engineering Business Unit receives MEPAC's support at the time of facility inspection. MEPAC performs analysis of corrosion in component levels. For example, minute construction or structure of a relay contact is observed through an electronic microscope (see Fig. 9). If any color change or attachment area is observed, we compare these areas with a normal product through the determination of constituent elements by component analysis and distribution measurement. In this manner, the degree of corrosion and deterioration is identified.

2.5 Diagnostic Technology for Deterioration in Polymer Materials

Insulation frames, rubber, grease, and other polymer materials are required to assure a variety of functions according to their applications, such as insulation property, mechanical strength, and lubricity.

Insulation frames are required to have high insulation performance and mechanical strength.

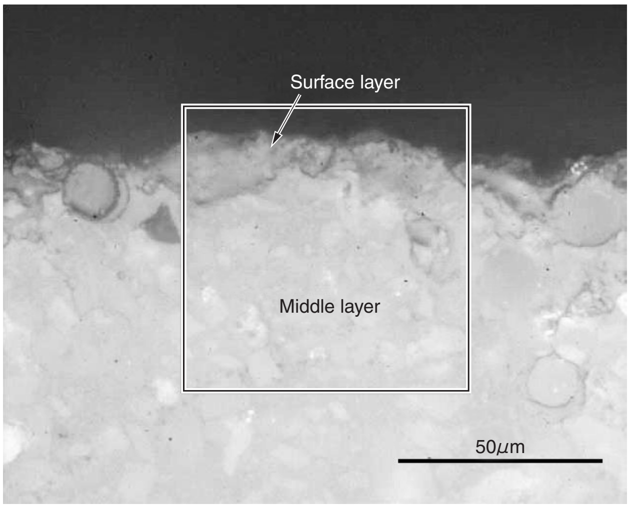


Fig. 10 Cross-Section of Insulation Material

A photo of an insulation frame cross-section taken through an electronic microscope is shown, where surface deterioration is developing.

Under the joint research activities between MEPAC and CHUBU Electric Power Co., Inc., a method of life expectancy diagnosis for insulation deterioration has been established with using an infrared spectrophotometer to quantitatively analyze the insulation resistance on the frame surface and deposited materials produced by the deterioration. With these analytical technologies to examine chemical structures of grease agents and abraded metals, we can diagnose grease usage and deterioration factors. Fig. 10 shows a cross-section of insulation material and Fig. 11 shows an imaging display.

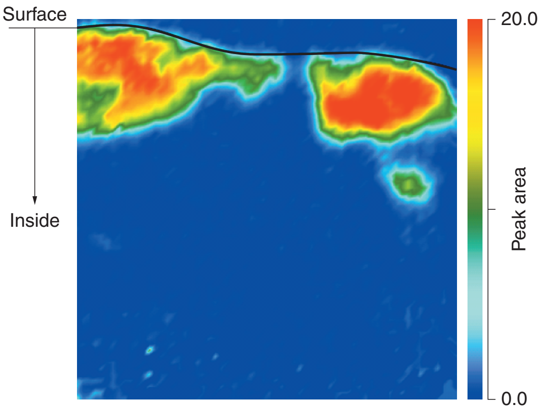
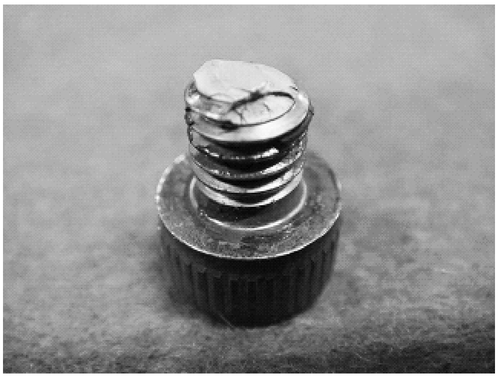
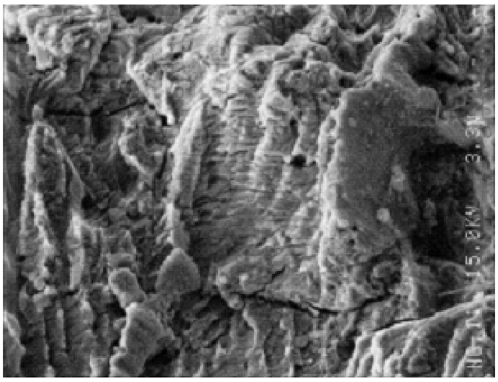


Fig. 11 Imaging Display

An imaging display is shown in **Fig. 10**. It shows a concentration of a hydroxyl group in the frame. This image suggests that the concentration of the hydroxyl group is high on the surface of the insulation frame as a result of secular deterioration.



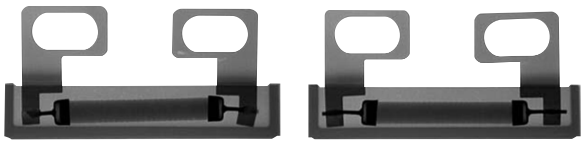
(a) Ruptured bolt



(b) Image of fracture surface

Fig. 12 Image of Ruptured Bolt and its Fracture Surface

A ruptured bolt and its fracture surface are shown, enlarged for observation by an electronic microscope. A pattern with stripes (striation) can be identified. It is caused as a result of fatigue destruction.



(a) Faulty item (b) Sound item

Fig. 13 Soft X-Ray Image of Cement Resistor

A fluoroscopic image of a cement resist shown in **Fig. 13** is taken by soft X-ray fluoroscopy. Image (a) is a faulty item, and (b) is a sound item. In the faulty item, a deformation can be confirmed in the shaft of cement resistor.

3 Technologies for Prevention of Faults and Recurrence Prevention

3.1 Recurrence Prevention of Faults

In many cases of investigation into product failures, possible causes are mostly due to breakage in structural components, presence of foreign substances, corrosion, poor contact, and short-circuiting. At MEPAC, its own technologies and facilities are effectively used to make elaborative investigations into causes of problems for prevention of recurrence. As shown in **Fig. 12**, for example, the cross-sections of breakage, fracture, and disconnection in structural components are checked with macroscopic and microscopic analysis. This is done in order to find out the mechanisms of destruction by identifying any destruction mode of fatigue, shocks, stress corrosion cracking, start of destruction, or the direction of development. In this manner, the result of analysis is actively utilized for design improvement and the prevention of recurrence.

3.2 Technologies for Prevention of Faults with Sound Item Analysis

Sound item analysis is an approach to discover any deficiencies inside a component so that potential damage cannot lead to the danger of destruction in the future. **Fig. 13** shows an example of a soft X-ray image of a cement resistor. By examining the internal structure in non-destructive mode, it is possible to discern sound items from faulty items. At MEPAC, ICs, Insulated Gate Bipolar Transistors (IGBTs), printed circuit boards, and other purchased parts, are checked in either non-destructive mode or destructive mode to quantitatively evaluate internal conditions of these parts according to the analytical check list. All this work contributes to quality improvement for the adopted parts and components.

3.3 Reliability Evaluation Test

In order to predict or prevent the occurrence of failures in purchased parts, products, and materials, the reliability evaluation test is carried out to estimate the failure rate and/or residual life by actualizing any potential defects under the accelerated conditions. At MEPAC, its evaluation conditions and standards are uniquely devised based on past experience to ensure the evaluation can be conducted in coordination with the existing environment.

4 Technologies for Hazardous Substances Analysis Based on Environmental Regulations

4.1 Analysis for the Restriction of Hazardous Substance (RoHS) Directive (Approved by ISO17025)

RoHS or REACH (Registration, Evaluation, Authorization and Restriction of Chemicals), and such hazardous substance control regulations have been widely accepted all over the world, and various methods of evaluation have been legislated at the same time. To create environmentally conscious products, it is essential to understand chemical substances information of these products. MEPAC has been awarded the international certificate "ISO17025 'JISQ17025'" that is approved by a trusted third party. Thus, we can offer higher reliability as well as high-level analytical data.

4.2 Trace PCB Analysis

Parts of power transformers, reactors, instrument transformers, and rectifiers manufactured in 1954 to 1972 used PCB-type insulation oils. Since 1972, production of all equipment containing PCB was abolished. When a transformer or other electrical equipment suspected of containing even trace amounts of PCB would be abandoned as an industrial waste, MEPAC made it a policy to measure the PCB concentration based on the Waste Disposal Law and the Law Concerning Special Measures Against PCB Waste. Since July 2010, it has become necessary to take a measured approach based on the "Manual for Simplified Measurement Concerning trace PCB Contained in Insulation Oils" when a manufacturer wants to make proper treatments for abolished electrical equipment. MEPAC has promptly investigated some measuring approaches to take analytical measurements in a timely manner. Fig. 14 shows a view of PCB analysis with a gas chromatography analyzer.

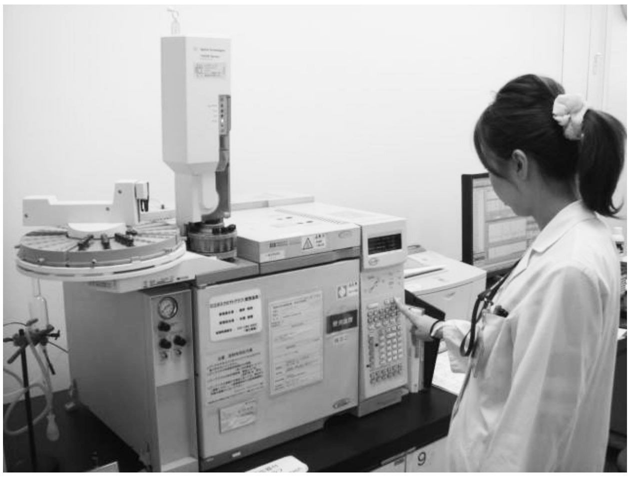


Fig. 14 PCB Analysis by Gas Chromatography Analyzer

A view of analysis with a gas chromatographic analyzer is shown. By a pre-treatment operation based on the official analytical method, the PCB particles contained in insulation oil are separated and recovered for the analysis.

5 Postscript

MEPAC is in charge of a variety of jobs such as environmental measurements, investigation into materials to be used, and a wide range of analytical business. In close cooperation with the respective plants and divisions, this organization discloses various useful data and offers proposals for possible countermeasures and ideas based on its data analysis.

In order to provide our customers with high-quality environmentally conscious products and maintenance services, and to respond promptly to newly legislated environmental regulations, we will continue to upgrade our technological levels of analysis and testing so that our tasks behind the scenes can result in substantial supports for the related sectors.