Technologies of Environmental Diagnostics to Support Efficient Repair and Maintenance Service Works

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Abstract

We developed a couple of devices that continuously monitor an installation environment and support the improvement of environmental stress.

The first device is an insulation deterioration monitor that has an output that predicts the tendency for insulation deterioration from the measurement of the temperature and humidity around the target equipment, the dew point temperature, and the degree of contamination, which then activates an alarm and a humidity reduction device in the cubicle.

The other device uses the auxiliary relay as a sensor and expose it to the same environment as the actual device. The corrosive gas level from continuous monitoring of contact resistance is estimated, and the device helps us by identifying an optimum replacement time for electrical parts, such as the auxiliary relay.

With the aid of such devices and by quantifying the progress of deterioration due to environmental stress, and by removing or reducing the various negative factors that have been identified, it is possible to greatly contribute to the prevention of challenges caused by environmental factors and the reduction of risks for failure.

1 Preface

The deterioration of substation equipment and plant electrical facility is greatly affected by environmental stress. It is important to identify and deal with these factors. We, therefore, developed the following two devices and are currently conducting verification tests.

(1) Insulation deterioration monitoring device

This device monitors the changes in temperature and humidity (dew point temperature) and degrees of pollution (equivalent salt deposit density) in environmental stress and detects signs of insulation deterioration.

(2) Electrical contact deterioration sensor

This device monitors the degree of contact deterioration due to the corrosive environment on electrical parts such as auxiliary relays.

This paper introduces the environment diagnostic devices using these means of condition monitoring.

2 Environment Diagnostic Device

2.1 Insulation Deterioration Monitoring Device (Insulation Deterioration Sign Monitoring)

2.1.1 Background and Purpose

Insulation deterioration of insulating materials used in high-voltage distribution panels or switching devices is greatly related to the presence of dust accumulated on the insulation surface and ambient moisture, in addition to moisture-absorbing conditions (dew condensation) on the insulation surface.

If these factors are adequately monitored, it is possible to predict the deterioration of insulation in insulating materials.

According to our experiments thus far, the heat capacity of the insulation materials used in switching devices such as vacuum circuit breakers, is relatively large, and the temperature change slowly follows that of the ambient temperature about 10 to 20 minutes later. It is also known that the leakage current on the insulation surface correlates with the surface contamination level and ambient humidity. It is,

however, difficult to constantly monitor the degree of pollution. The correlation between the annual average airborne dust amount inside the distribution panel and the annual pollution level of the equipment surface has, therefore, been verified over several years. The relational expression between the average airborne dust amount and the degree of contamination of the equipment surface was derived. By doing this, we derived the current equivalent salt deposit density (contamination degree) based on the number of days elapsed after cleaning, and developed a device to estimate the insulation deterioration by continuously monitoring only the temperature and humidity.

2.1.2 Specification

The device consists of a sensor that measures the temperature and humidity near the insulation materials inside the cubicle, one that stores and processes data, and another that sends these data values to a Web server to display them on a website. Fig. 1 shows the outline of the insulation deterioration alarming device.

2.1.3 A Monitoring Case

This equipment was installed in one of the JIS cubicles located outdoors at our company, where data was acquired and a field test was conducted to verify the effectiveness. Fig. 2 shows a display screen of the insulation deterioration monitoring device. Temperature, humidity, insulation surface temperature (estimated value), dew point temperature, contamination degree (estimated value), easiness of dew condensation, and difference between the surface temperature and the dew point are displayed. According to the conditions of respective data, an insulation deterioration alarm (dew condensation state and/or equivalent salt deposit density) or a start-up signal for the dehumidifier is sent. Fig. 3 shows an enlarged graph (visualization) of Fig. 2.

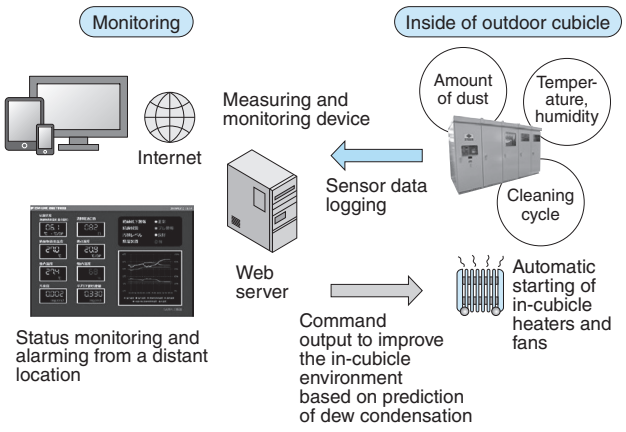


Fig. 1 Outline of Insulation Deterioration Alarming Device

An example of this alarming device is shown. (Patent No.2019-20271, Name of Invention: Method and Equipment for the Evaluation of Reduction of Insulation Resistance in Insulating Materials or Recovery from Reduced State)

2.1.4 Future Development

This device measures the temperature and humidity to predict dew condensation and insulation deterioration. Currently, we are beginning to develop an advanced environmental monitoring system by combining this insulation deterioration monitoring device with other environmental monitoring devices. This system can be expected to prevent problems

Fig. 2 Display Screen of Insulation Deterioration Monitoring Device

This system is accessible by web browsers such as Safari and Google Chrome. The monitoring information is available if the URL address is known. The control screen is, however, password-protected.

Fig. 3 Enlarged Graph of Insulation Deterioration Alarming Device

By clicking on the graph enlargement button in Fig. 2, the presently displayed graph is enlarged. Data in the recent 24 hours can be checked.

caused by deterioration of insulation of electrical facility or equipment due to environmental changes.

2.2 Electrical Contact Deterioration Sensor

2.2.1 Technical Background and Purpose

Regarding the installation environment for electrical facilities, as a means for evaluating the corrosive environment, there are equivalent salt deposit density measurements (contamination degree measurement) and corrosive gas concentration measurements.

Since the progress of corrosion is greatly affected by temperature and humidity, there are, however, problems such as a large deviation from the progress of corrosion in actual equipment simply by evaluating the above parameters.

The sensor developed this time uses a method that monitors the increase in contact resistance (which is an index of deterioration of electrical contacts) using an actual device (auxiliary relay) in an actual environment. As a result, quantitative evaluation results that are extremely close to the actual deterioration situation were obtained.

2.2.2 Specifications

This sensor is a compact and lightweight on-site installation type that can be installed in an electric room, distribution panel, or control panel. The same auxiliary relay used in the actual panel is exposed in the environment, and the contact resistance, which is a barometer of corrosion progress, is continuously monitored. Fig. 4 shows an external appearance of the electrical contact deterioration sensor. Fig. 5 shows the installation status inside the distribution panel.

Fig. 4 Electrical Contact Deterioration Sensor

An external appearance of an electrical contact deterioration sensor is shown. The same auxiliary relay, as used in actual panel, is utilized as a sensor and all corrosive environments can be monitored.

2.2.3 A Monitoring Case

This sensor was installed in two electrical rooms (one with a relatively good environment and another with a bad environment) in a sewage treatment facility to monitor the deterioration of contacts. Fig. 6 shows an example of changes in contact

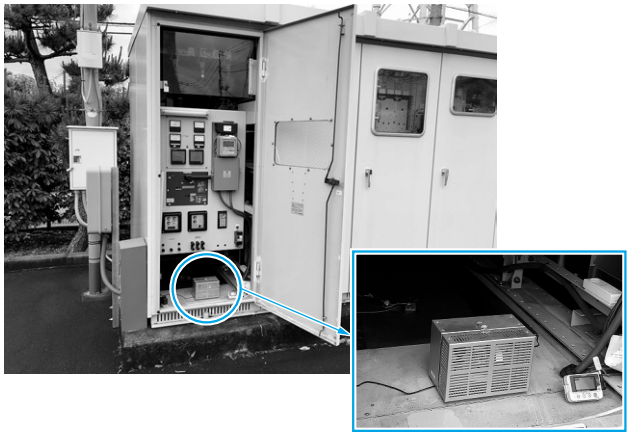
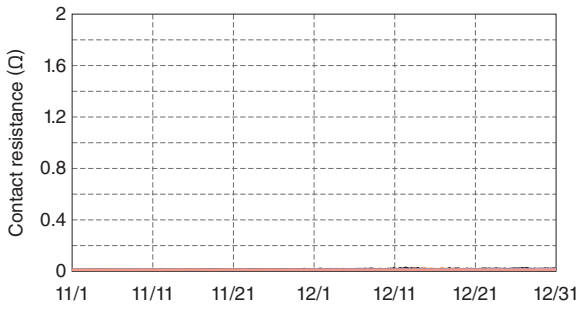
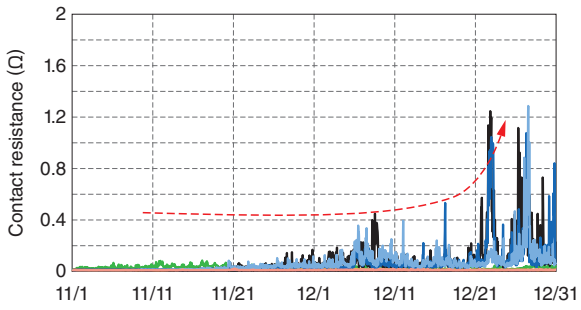


Fig. 5 Installation Status inside Distribution Panel

An example of installation status inside an outdoor cubicle is shown.



(a) Electrical room under relatively good environment



(b) Electrical room under bad environment

Fig. 6 Example of Changes in Contact Resistance over Time

The changes over time of the contact resistance of each electric room is shown. In an electrical room with poor conditions, an increase in contact resistance can be seen within just two months.

resistance over time in each electrical room. Compared to the electrical room with a good environment, the data of the electrical room with a bad environment showed an increase in the contact resistance at the contact point within just a few months, we confirmed the risk of system failure due to poor contact[1].

2.2.4 Future Development

In addition to being used as a standalone, this sensor can perform remote monitoring in real time by adding a communication function. It can be installed in multiple electrical rooms and distribution panels to centrally monitor the entire facility. It is expected that this will be a more realistic assessment source that will be useful for prioritizing repair and maintenance service actions (optimization of repair and maintenance service plans and the cycles) such as parts replacement and repair of each electrical room and distribution panels.

3 Postscript

We introduced an example of the installation environment diagnosis technology developed by our company. In the future, while promoting the practical application of this environmental diagnosis technology, we will propose practical evaluation and improvement of the installation environment by quantifying environmental stress in the customer's electrical facility. In doing so, we aim to lead an effective preventive maintenance service such as prevention of challenges due to environmental factors and reduction of risk of failure.

《Reference》

(1) "Reduction of Failure Risks by Installation Environment Diagnosis 1-9", Meiden Jiho Vol.362, 2019/No.1, p.30 (in Japanese)