Comprehensive Service for Smart Industrial Safety, Which Improves Maintenance and Inspection Efficiency and Delivers Predictive Maintenance

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ABSTRACT

Utilities of industry and energy infrastructures such as power distribution equipment are faced with urgent challenges to overcome issues of aged deterioration of equipment, long-term shortages and aging of workers for repair and maintenance, and capability degradation to pass down technologies and skills. Demand is thus increasing for smart maintenance, improved inspection efficiency, and predictive maintenance. Fuji Electric offers "Comprehensive Service for Smart Industrial Safety," in which we collect and analyze a variety of information from the equipment to plan maintenance planning, monitor equipment, and suggest maintenance management measures, optimizing equipment maintenance. We are expanding the application of these services by adding new services, such as equipment operating condition and trend monitoring and rotating machine vibration monitoring.

1. Introduction

The fields of industrial and energy infrastructure are facing a number of issues, including the deterioration of equipment due to age, long-term labor shortages and the aging of the repair and maintenance workforce, and a rapid decline in the ability to pass down technologies and skills. In addition, in order to maintain a healthy infrastructure, it is necessary to respond to various changes, such as the increasing severity of disasters, the risk of terrorism, and the advancement of a digital society defined by new technologies.

To address these challenges, the Public-Private Council on Smart Industrial Safety was established by the Ministry of Economy, Trade and Industry on June 26, 2020, and the Smart Industrial Safety Action Plan has been proposed for the field of electrical security. In accordance with this action plan, electrical equipment suppliers, including Fuji Electric, and customers who operate equipment are asked to maintain and enhance their maintenance capability and improve productivity to advance smart maintenance for electric equipment. They accordingly aim to promote the proliferation and expansion of smart industrial safety technologies and to introduce various new technologies to industrial safety service sites, such as the Internet of Things (IoT), artificial intelligence (AI), wearable devices, and drones. This paper describes Fuji Electric's "Comprehensive Service for Smart Industrial Safety," which contributes to improving the efficiency of maintenance and inspection and implementing predictive maintenance.

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2. Services Provided by Fuji Electric[1]

Figure 1 shows an overview of Fuji Electric's smart integrated service solutions that use digital transformation (DX).

The Ministry of Economy, Trade and Industry defines DX as "efforts by companies to establish competitive advantages, respond to significant changes in business environments, utilize data and digital technology, and reform products, services and business models, as well as organizations, processes and company culture, based on the needs of customers and society."

The Comprehensive Service for Smart Industrial Safety, described in detail in Chapter 4, aims to improve efficiency by innovating maintenance operations, such as routine patrol inspection, conducted by human resources with digital technologies. At the same time, most of these maintenance work requires human senses and intuition, which cannot be replaced by digital technologies or tools. Therefore, it is also necessary to continue training workers and improving efficiency using digital technology.

Fuji Electric will integrate service solutions that apply digital technology in both aspects to offer smart integrated services, with the maintenance work made more smart, efficient and optimal.

3. Equipment Maintenance Related Challenges[2]

Industrial infrastructure such as power distribution equipment and factories containing production equipment are typically faced with challenges of operating equipment stably and reducing maintenance costs. Until now, equipment has been managed so that stable operation can be maintained through time based maintenance (TBM), which is carried out in the form of regular manual inspections and maintenance

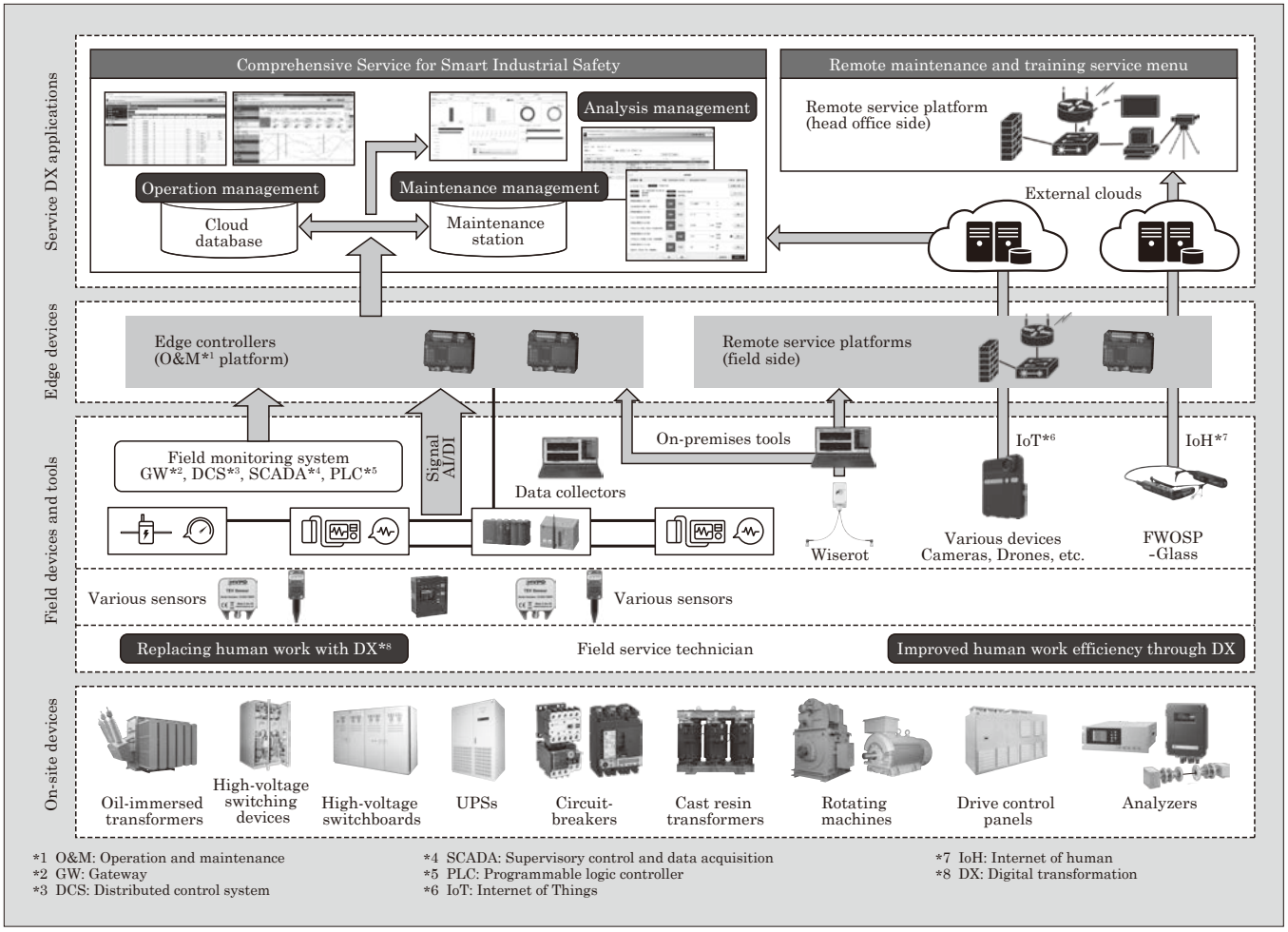

Fig.1 Overview of smart integrated service solutions

operations. On the other hand, condition based maintenance (CBM) involves the collection of various information pertaining to equipment and the identification and analysis of equipment conditions to perform maintenance work depending on the conditions. CBM is expected to optimize inspections, improve efficiency, counter the shortage of personnel required for maintenance, and enable predictive maintenance through the analysis of condition information. To achieve this, we need to promote "smart industrial safety" by applying IoT and digital technologies to maintenance work that was manually conducted; automating the collection, recording, and management of information; and applying software to analyze the collected data in an integrated manner.

4. Fuji Electric's "Comprehensive Service for Smart Industrial Safety"

In fiscal 2022, Fuji Electric began offering its Comprehensive Service for Smart Industrial Safety, which uses IoT and AI to optimize equipment maintenance, from maintenance planning to equipment monitoring and the proposal of maintenance management measures for power distribution equipment.

4.1 Overview of the "Comprehensive Service for Smart Industrial Safety"(3)

Figure 2 shows an overview of the Comprehensive Service for Smart Industrial Safety. The Comprehensive Service for Smart Industrial Safety consists of operation and maintenance (O&M) service applications that conform to ISO 18435 (O&M integrated model). By sharing equipment information between customer worksites, administrators, and Fuji Electric, mainly through an Azure*1 based cloud system, we will build a smart industrial safety system.

As shown in Fig. 2, by using a cloud system, worksite personnel, administrators, and Fuji Electric can share and utilize maintenance related information even from locations far from the worksite, and by using service applications on the cloud, cumbersome tasks such as software update and management become unnecessary.

The collected data ranges from operating information from on-site devices, measurement data from sensors and meters, maintenance records, inspection

*1 Azure is a trademark or registered trademark of Microsoft Corporation.

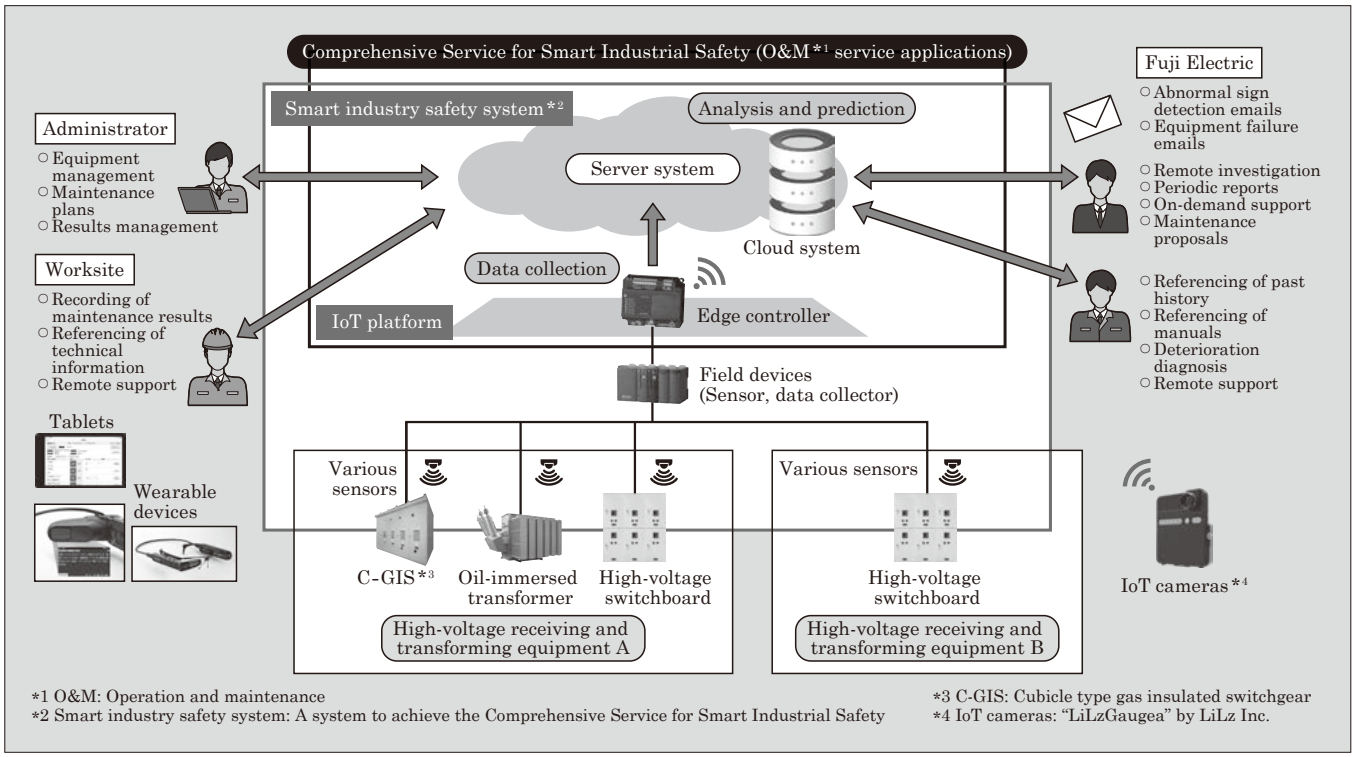

Fig.2 Overview of the "Comprehensive Service for Smart Industrial Safety"

records, and to daily and monthly reports. It is expensive and difficult to build, install, and maintain data servers that accumulate data over periods of ten years or more at the worksite. Furthermore, the worksite is required to bear all of the data security risks. Cloud systems allow customers to maintain and manage data for a long time by always using the latest security technology.

4.2 Functions of the "Comprehensive Service for Smart Industrial Safety"

Figure 3 shows the functional configuration of the Comprehensive Service for Smart Industrial Safety. The Comprehensive Service for Smart Industrial Safety consists of the following three functions.

(1) Operation management functions

The management of online information collected from the desired equipment

(2) Maintenance management functions

The management of offline information such as work plans, work instructions, work results, and maintenance results mainly pertaining to maintenance work performed by people

(3) Analysis management functions

The integration of various kinds of data and the implementation of "individual analysis" and "advanced BI analysis." Business intelligence (BI) analysis refers to the analysis and visualization of various company data for management and business purposes.

These functions systematically collect online equipment information, such as operation state, failure, and deterioration data, as well as offline information pertaining to maintenance work, such as work contents and inspection records, and store them in a database to perform multidirectional analysis. This function enables users to monitor operating information and

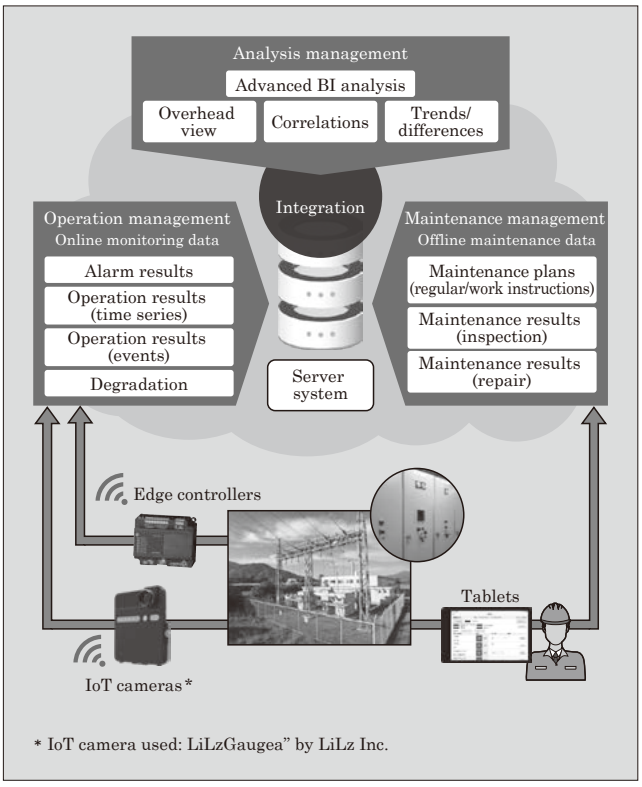

Fig.3 Functional configuration of the "Comprehensive Service for Smart Industrial Safety"

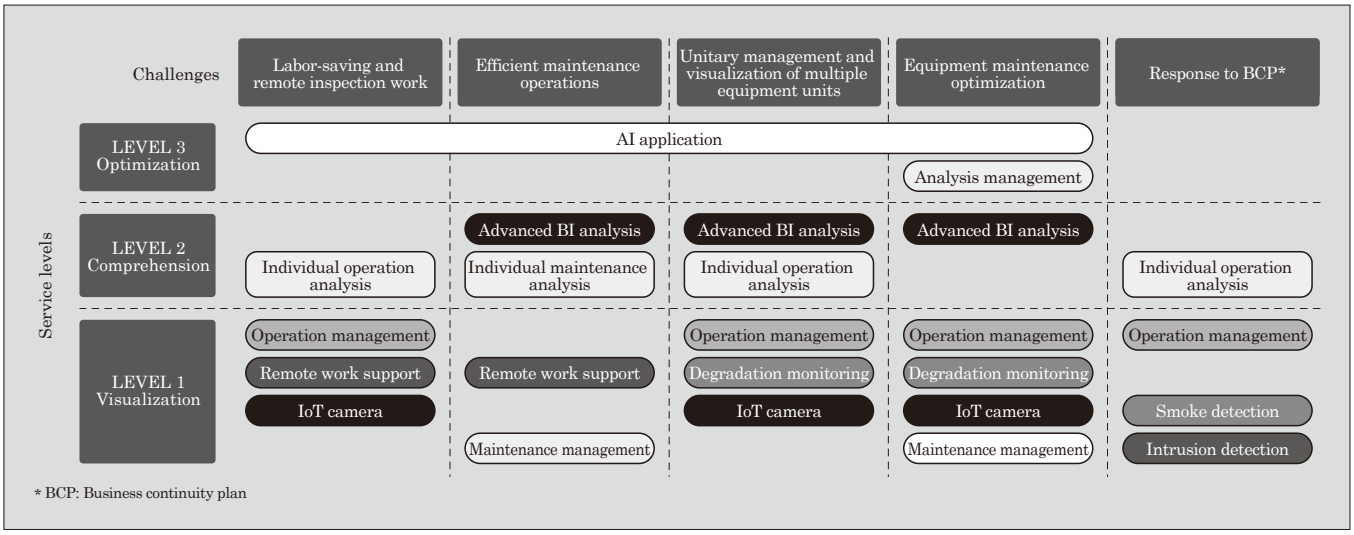

Fig.4 Smart levels in maintenance operations

deterioration diagnosis information by viewing them in the form of trends, improve maintenance efficiency by utilizing digital tools, and check equipment conditions before and after inspections by comparing them with inspection results. Furthermore, changing the cycle of periodic inspections based on the details of analyzed information can reduce maintenance costs and catching failure signs through data analysis and performing proper maintenance can stabilize equipment operations.

4.3 Smart maintenance work that the "Comprehensive Service for Smart Industrial Safety" aimed for

Figure 4 shows the smart levels of maintenance work. As shown in the figure, the Comprehensive Service for Smart Industrial Safety categorizes challenges and smart levels at worksites, allowing users to gradually increase the level of provided services according to customer's maintenance situations.

(1) Level 1 (Visualization)

Visualization will promote the digitization of maintenance site information by introducing IoT devices, digitizing work records, and supporting remote work. These activities include visualizing work results and the maintenance conditions of equipment by acquiring digital images of equipment states through remote monitoring and IoT cameras, as well as by digitizing device deterioration monitoring information and inspection records. They also include disaster prevention and security such as fire prediction and intrusion detection.

(2) Level 2 (Comprehension)

Comprehension refers to individually analyzing the trends and differences in various types of operation and maintenance information and identifying challenges and improvements through BI tools that perform multifaceted advanced analysis such as overviews and correlations of various types of data. These analyses and diagnostic results lead subsequent inspections, maintenance, and updates.

(3) Level 3 (Optimization)

The optimization phase is aiming at achieving optimization through automated evaluation, diagnostic accuracy improvement, and sign detection by adopting AI engines suitable for individual tasks to provide integrated improvement services such as analysis and consultation regarding equipment conditions and maintenance needs from multiple perspectives. This phase has remained room where further technological advancements are still required. To reach this goal, we must strive to achieve visualization and comprehension together with customers. The Comprehensive Service for Smart Industrial Safety is a collaborative DX solutions for maintenance and safety services, in which Fuji Electric works closely with its customers to make the services more smart.

5. Application Examples

This chapter describes Fuji Electric's efforts at the Yamanashi Factory as an example of the application of the Comprehensive Service for Smart Industrial Safety. The Yamanashi Factory manufactures semiconductors and has promoted the smartness of the receiving and transforming equipment and other particularly important auxiliary equipment.

5.1 Visualization of the operating conditions of high-voltage receiving and transforming equipment

Figure 5 shows examples of the monitoring of operating conditions and trends for high-voltage receiving and transforming equipment. The operating conditions of equipment and their soundness can be understood visually by converting the operating conditions of the equipment into data and monitoring trends over long periods of time.

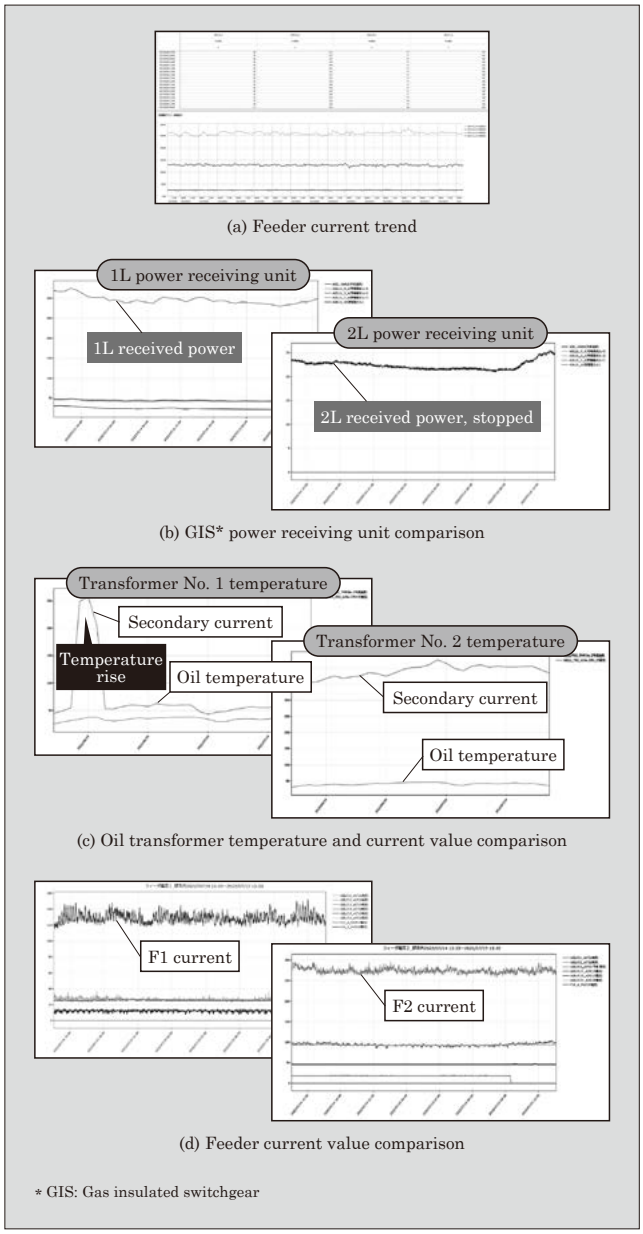

Fig.5 Examples of operating condition and trend monitoring of high-voltage receiving and transforming equipment

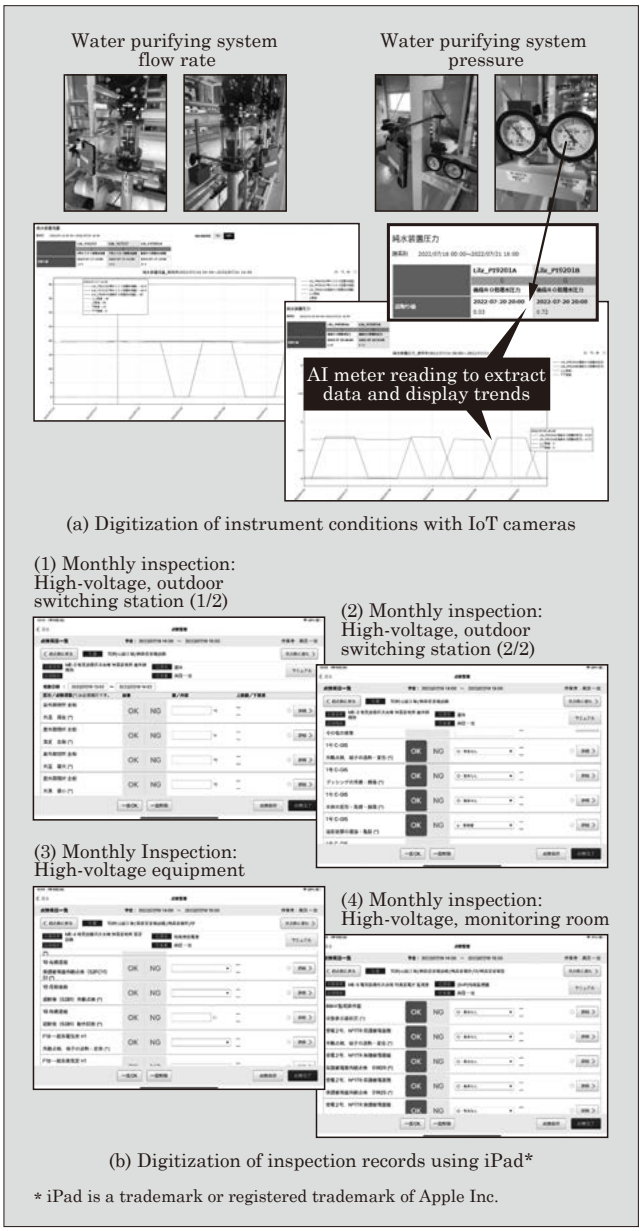

Fig.6 Examples of visualization of maintenance operations

5.2 Examples of visualization of maintenance operations

Figure 6 shows some examples of the visualization of maintenance operations. In conventional maintenance operations, the values of various instruments and meters were checked visually by personnel during routine patrol inspections and recorded on paper. These can now be automatically read and recognized using AI-applied IoT cameras and recorded as digital data. Similarly, inspection records that were conventionally recorded on paper are being digitized and made more efficient by using tablet devices such as iPads*2.

*2 iPad is a trademark or registered trademark of Apple Inc.

5.3 Integration of operation monitoring and maintenance management data, and advanced BI analysis

Figure 7 shows an example of the application of BI tools. This is an example of a trial for efficiency analysis of inspection operations through the integration of maintenance management data, such as inspection plans and inspection performance records, with operation monitoring data. In addition to differences in inspection time and comparisons between plans and results, the tool can be used to check the operating conditions of equipment before and after each inspection to provide feedback on the proficiency of inspection workers and the optimization of inspection sequence. BI tools can analyze correlations and trends of various types of information in multiple ways, but the information and analysis results are often specific to the target

Fig.7 BI tool application example

equipment and maintenance personnel. Fuji Electric will cooperate with customers who operate and manage equipment by introducing the Comprehensive Service for Smart Industrial Safety and share information with them to add value and improve maintenance and efficiency.

5.4 Rotating machine vibration monitoring

Figure 8 shows an example of vibration monitoring for a rotating machine. Rotating machines are commonly used for production equipment such as generators, pumps and compressors, and when they stop operating due to failures, production plans are greatly affected. The Comprehensive Service for Smart Industrial Safety provides predictive maintenance through vibration monitoring by utilizing the rotating machine failure sign monitoring system "Wiserot." It analyzes information from wireless vibration sensors by using an original algorithm, detects bearing failures, and suggests maintenance accordingly.

5.5 Electrical room fire sign monitoring

Figure 9 shows an example of fire sign monitoring.

The Comprehensive Service for Smart Industrial Safety provides a function for monitoring warning signs of fire accidents, which are often seen in electrical rooms and switchboards. By linking a fire sign detection system from NOHMI BOSAI LTD., which can

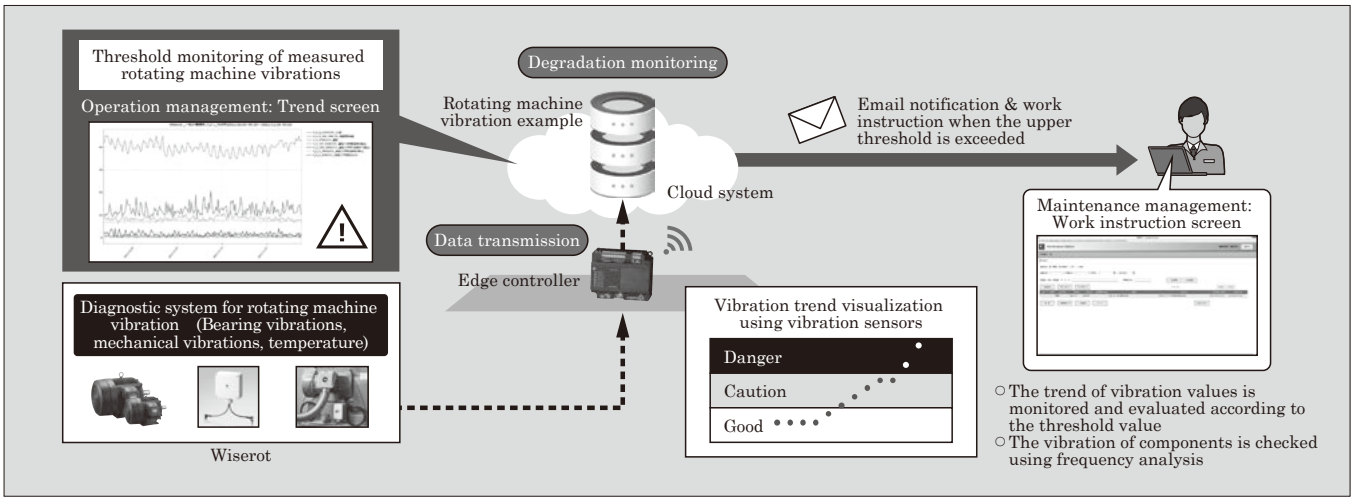

Fig.8 Rotating machine vibration monitoring example

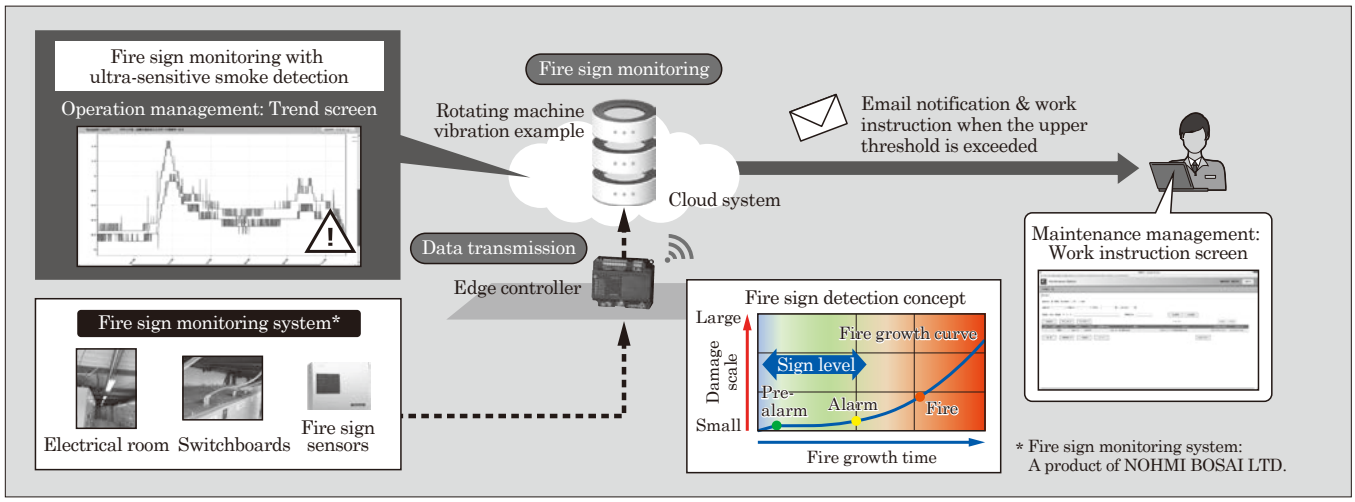

Fig.9 Example of sign monitoring for fires

detect the outbreak of smoke as a warning sign from the earliest stage of a fire, the cloud monitoring function of the Comprehensive Service for Smart Industrial Safety can detect the initial signs of fire and respond promptly and thoroughly by issuing not only on-site alarms, but also email notifications.

6. Postscript

This paper has described smart industrial safety services that contribute to improving the efficiency of maintenance and inspection and achieving predictive maintenance. Fuji Electric will continue to improve its "Comprehensive Service for Smart Industrial Safety" by enhancing the deterioration diagnosis function, proactively incorporating various IoT devices and digital technologies to expand the scope of security operations and improving the interface to make it easier to understand the conditions. We also intend to strengthen our knowledge of advanced analytical technology obtained through accumulated data, build up our track record of verification and identification of effects through the use of demonstration equipment at our own factories, and work together with our customers to add even more value.

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