# Prediction and Diagnosis on Malfunction by Remote Monitoring System for Compressor

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*Mitsubishi Heavy Industries, Ltd. (MHI) has developed a remote monitoring system equipped with functions such as diagnosis of malfunction, prediction of malfunction and two-way communications for Mitsubishi compressors in order to offer enhanced after-sales service to the customers. In the process of development, a general-purpose computer and package software were adopted, and by applying the existing communication technology to ensure required security, the system was made easy to use for customers at low cost. The system can be effectively used to respond quickly to any possible malfunction, and the sign of malfunction can be predicted to avert the trouble, contributing to the reduction of down time and maintenance cost.*

## 1.Introduction

With the high function and low cost of the general-purpose computers, they have come to be used rapidly in wide fields ranging from offices to sites, setting the environment ready for making effective use of information technology (IT). Further, the demands from customers call for further improvement in services after the delivery of the product. In order to meet with such demands from customers a system capable of contributing to the improvements in productivity and efficiency has to be developed using the peripheral technologies integrated with the information technology.

This paper introduces a remote monitoring system developed by MHI to offer new services to the customers.

## 2. Outline

### 2.1 Purpose of development

The remote monitoring system capable of real-time collection of different types of information regarding compressor and driving machine (turbine, motor) using computer and communication technology can be effectively used for prompt response to any trouble in order to meet with customer demand for enhanced after-sales service.

The purposes of the remote monitoring system can be summed up as follows.

(1) Upkeep of continuous operation of the compressor and driving machine
(2) Reduction of down time
(3) Centralized control of machine operation, maintenance and regular inspection control information
(4) Realization of online consultation for maintenance service

### 2.2 Guideline for system configuration

In establishing the system, it is necessary to grasp the details of site information in a remote area in order to offer supports for operation and maintenance in addition to the unmanned operation of pipe lines for gas fields. Further, the system lower in cost and with excellent operability can be established by using a general-purpose computer.

The policies in detail for the development of monitoring system are given below.

(1) Use at unmanned operation site
(2) Use at any place (all over the world)
(3) Security function to protect against unauthorized access
(4) Confirmation of warning buzzer at the monitoring side during unmanned operation at the site,
(5) Identification of the cause and prompt response for compressor malfunction
(6) Access to information about the cause of trouble and countermeasure by customer and manufacturer

### 2.3 System configuration and specifications

The system is widely composed of the following three parts, with the system configuration shown in **Fig.** 1.

(1) Local site: The place where the customer plant (or machine) is located

The local site is composed of a router, a programmable logic controller (PLC) and a computer for collecting and sending data from vibration monitor. The computer is equipped with an A/D converter board to collect the oscillatory waveform.

(2) Satellite part: A means of communication to transmit customer's machine operation data to a remote site

The system uses satellite communication where no communication infrastructure is available and

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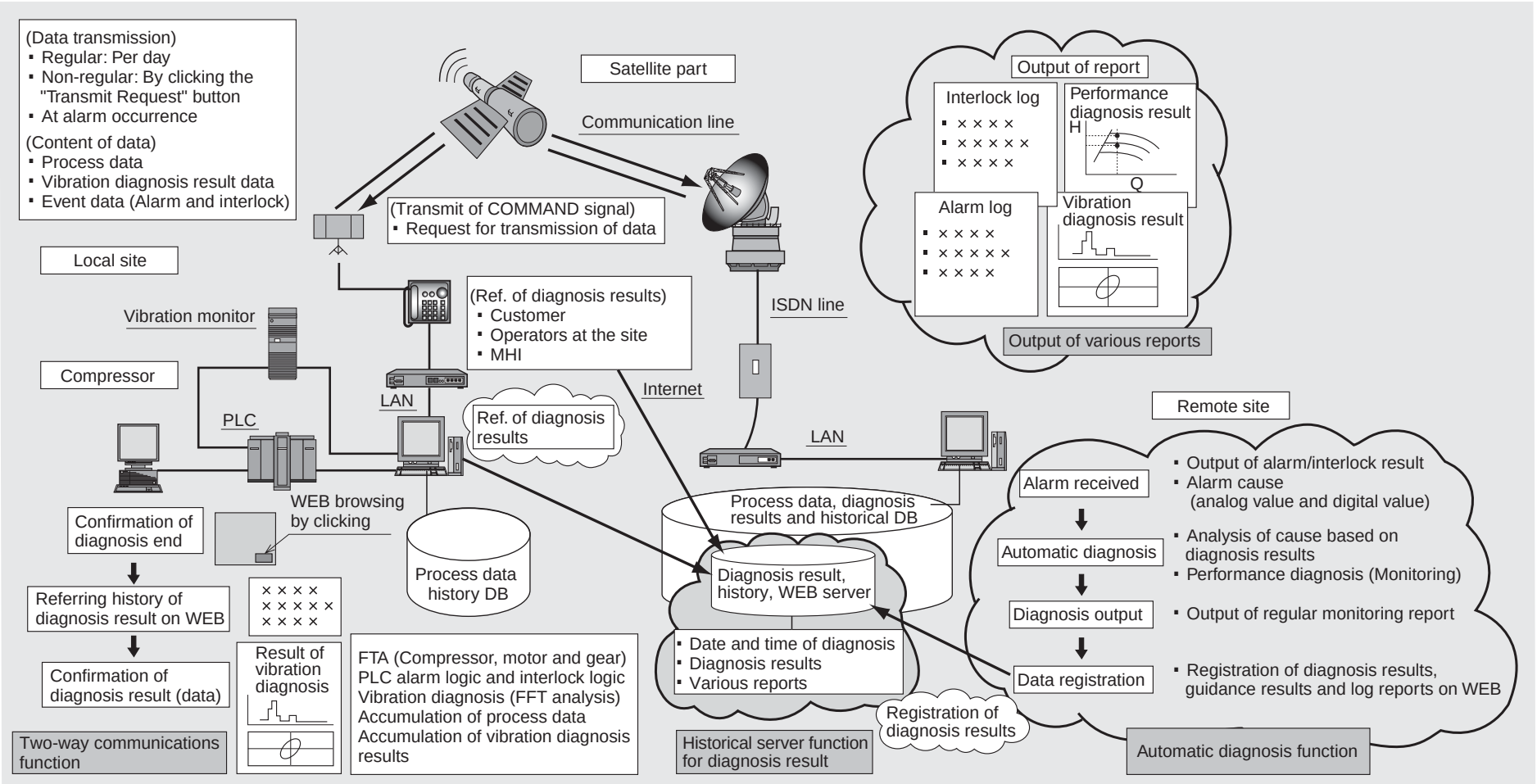


**Fig. 1 Outline of remote monitoring and diagnosis system**

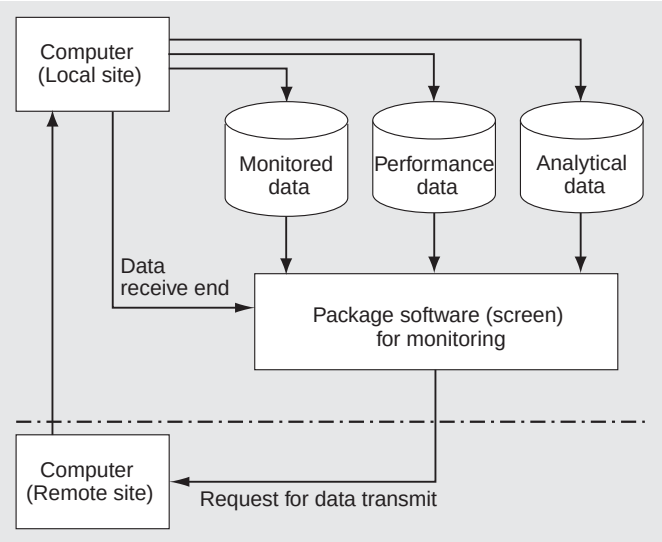


**Fig. 2 Software interface**

internet where communication infrastructure (telephones or internet) is available.

(3) Remote site: A remote place where the customer's operating condition is monitored and diagnosed.

The remote site is composed of a router and a computer for receiving data.

(4) Software within system

General-purpose computers and the package software for process monitoring are used in this system. This composition results in the following advantages:

- A low-cost monitoring system can be developed.
- Any manufacturer's PLC can be used only by changing the communication driver.
- The change of operation system (OS) or language have little effect on the specifications and operability.
- The screen can be easily changed when the composition of the peripheral machines of the compressor gets changed.

**Fig. 2** shows the interface for communication program and monitoring package software.

### 2.4 Security

In the remote monitoring and maintenance service business it is extremely important for the future to indicate the objective security level of the system to the customer. The system is provided with required security by making use of the existing technology.

(1) Router

The Challenge Handshake Authentication Protocol (CHAP) is set for routers, resulting in mutual authentication between routers to ensure security (**Fig. 3**).

CHAP is a protocol for security supported on the network. The protocol itself does not prevent the unauthorized access. It only identifies the remote end, while the router makes identification whether the access is authorized or not.

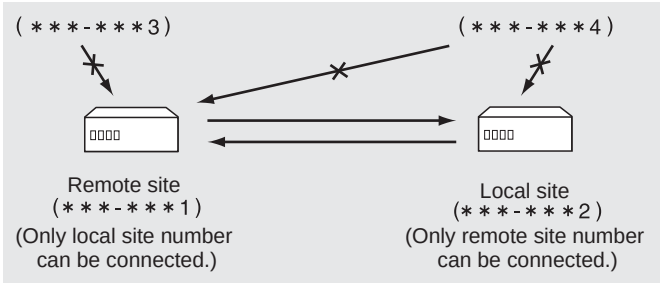


**Fig. 3 Security by using routers**

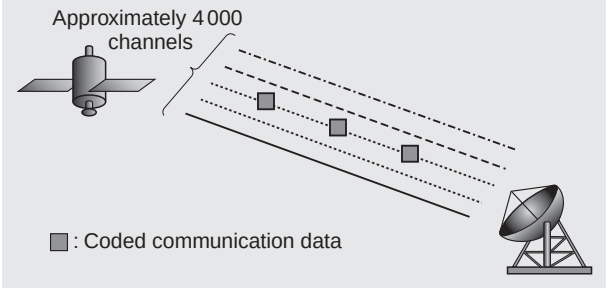


**Fig. 4 Security using satellite communication**

(2) Satellite communication

For communication from or to the satellite communication equipment, the security is ensured by random selection of frequency each time the communication is made and through coding of the transmit data (**Fig. 4**).

### 2.5 Data compression

Data is compressed according to its characteristics in order to reduce the data size, to shorten the communication time and to cut down the communication cost.

The transfer time is shortened to half and the communication cost further reduced by using the User Datagram Protocol/ Internet Protocol (UDP/IP) as the file transfer protocol. UDP/IP is a simple protocol and exchanges datagram without response for confirmation or guarantee for delivery.

### 2-6 System specifications

The specifications for the system are as given below.

(1) Connection between local site and remote site

- Regular (Auto)/Arbitrary (Manual)/At trouble (Auto)

(2) Monitoring screen

- Process data displayed on the system diagram (instantaneous value/past data)
- Performance curve
- Alarm/Trip
- Vibration analysis (FFT/Modal circle/ORBIT)

**Fig. 5** shows an example of the monitoring screen.

## 3. Main Functions

In order to achieve the purposes of the adoption of this system (described in Section 2.1), the following functions were developed.

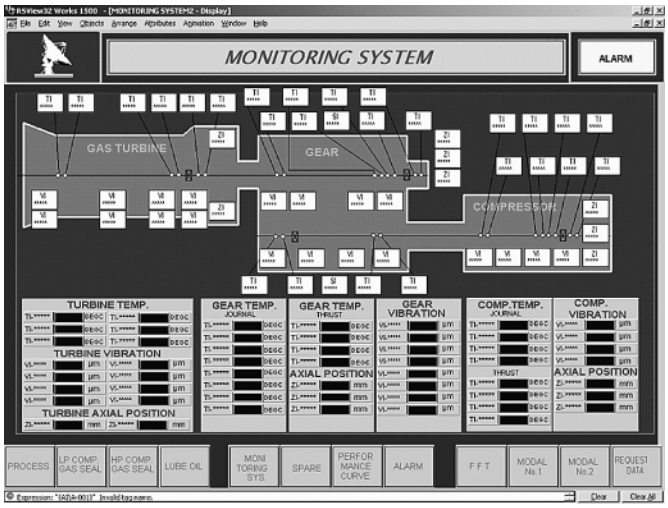


**Fig. 5 An example of monitoring screen**

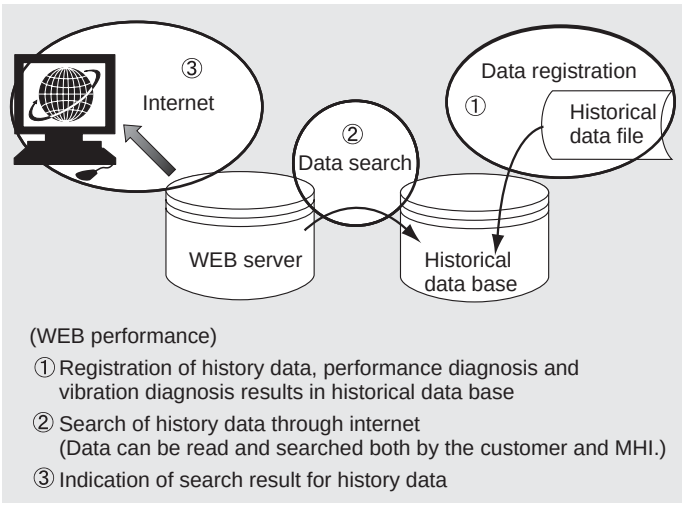


**Fig. 7 Outline of two-way communication**

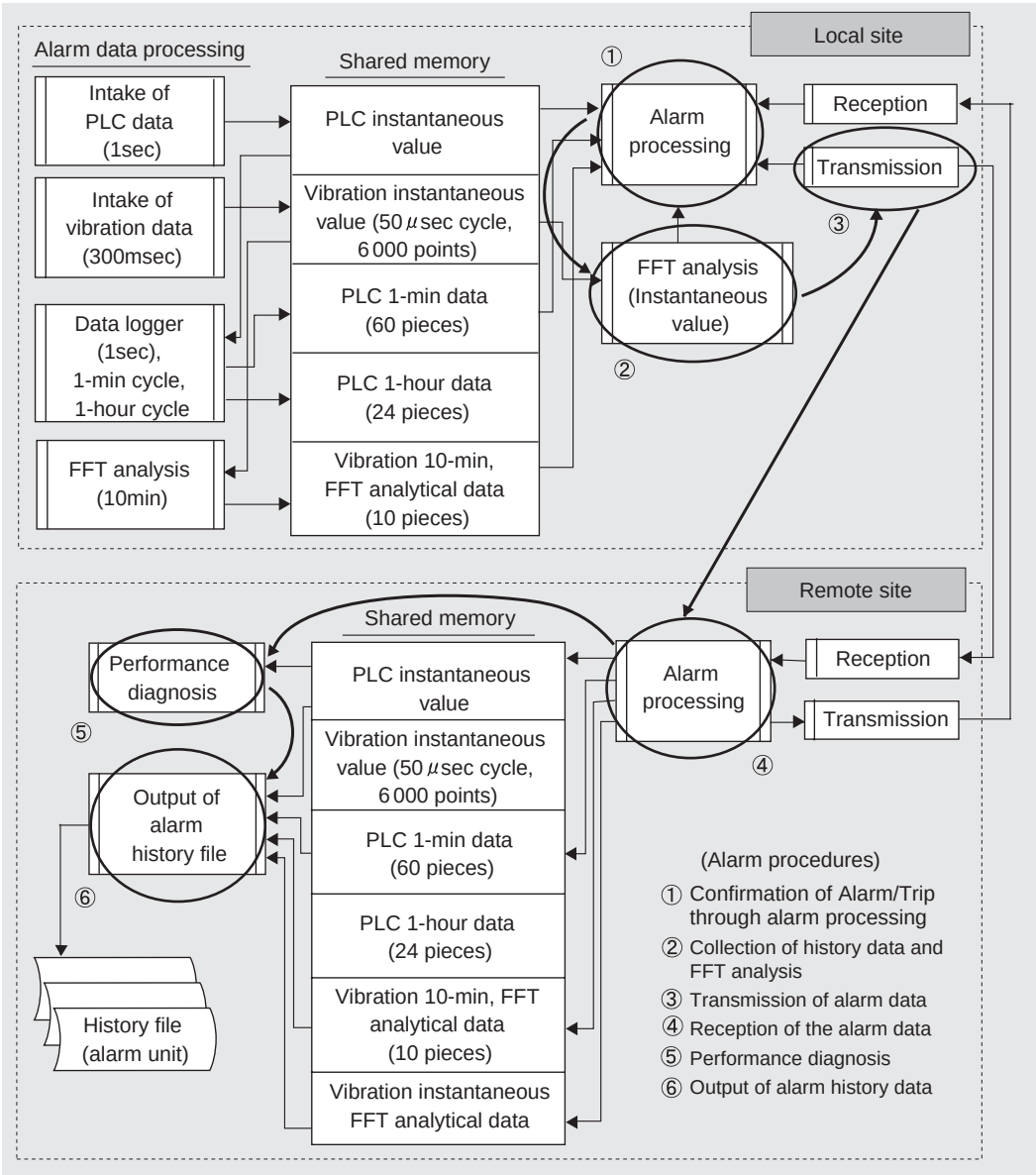


**Fig. 6 Data flow at malfunction detection**

### 3.1 Malfunction diagnosis function

The diagnosis function is a primary diagnosis function for early detection of the malfunction of compressor or driving machine in order to find the cause factor as soon as possible to take necessary measure. With the alarm or trip activated, this function searches the relative cause factor from Fault Tree Analysis (FTA) and indicates the cause of the concerned item together with the countermeasure thereof.

### 3.2 Malfunction prediction function

The prediction function constantly keeps the process data stored in the historical database for process data during normal operation. On detecting the malfunction, the function carries out FFT (Fast Fourier Transform) analysis of the vibration data at the compressor side before transmitting the FFT analysis data together with the process data and the historical data of the processes to the remote site. The data flow of the malfunction detecting function is given in **Fig. 6**. Further, even if the process value has not reached the level set in the alarm, the function predicts that the process value will reach the set level in near future on the basis of the process data transition for the past one month, and prevents the trouble from occurring.

### 3.3 Two-way communications function

The two-way communications function provides the information regarding the alarm history and result of malfunction diagnosis (result of FTA analysis) not only to the manufacturer but also to the customer, for sharing the information. As a means of two-way communications the following two items are included in the alarm/trip history and database of malfunction diagnosis result based on FTA in order to allow data search when needed. Further, the data (information) is put on the WEB so as to enable searching and browsing of the data from both sides (customer and MHI). The schematic diagram of the database and WEB function for the two-way communications function is shown in **Fig. 7**. This function makes it possible for the engineers, operators, manufacturers or any other related people to learn the site situation correctly from a place different from the site.

### 3.4 Automatic diagnosis function

On receiving the alarm/trip signal from the local site the automatic diagnosis function carries out malfunction analysis automatically on the basis of FTA in addition to the vibration analysis and performance diagnosis. It then picks out only the meaningful data out of the huge amount of data and offers to the customer as fundamental data for comprehensive criteria. **Fig. 8** shows a sample of the automatic diagnosis screen.

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## 4. Conclusion

The newly developed system can tell the customer about the measures to be taken at the time of alarm/trip occurrence through remote monitoring, diagnosis of the customer's machines and automatic analysis based on FTA. In addition to this, the trend data, performance diagnosis and frequency analytical data can also be referred to as additional information. Further, since the diagnosis results are displayed on WEB, the data can be offered to the customer as a service as an added value of the compressor. MHI is determined to make further efforts towards realization of more effective maintenance control and prolonged life of the equipment by making effective use of the ever-advancing communication technology and making the system easier to introduce and use.

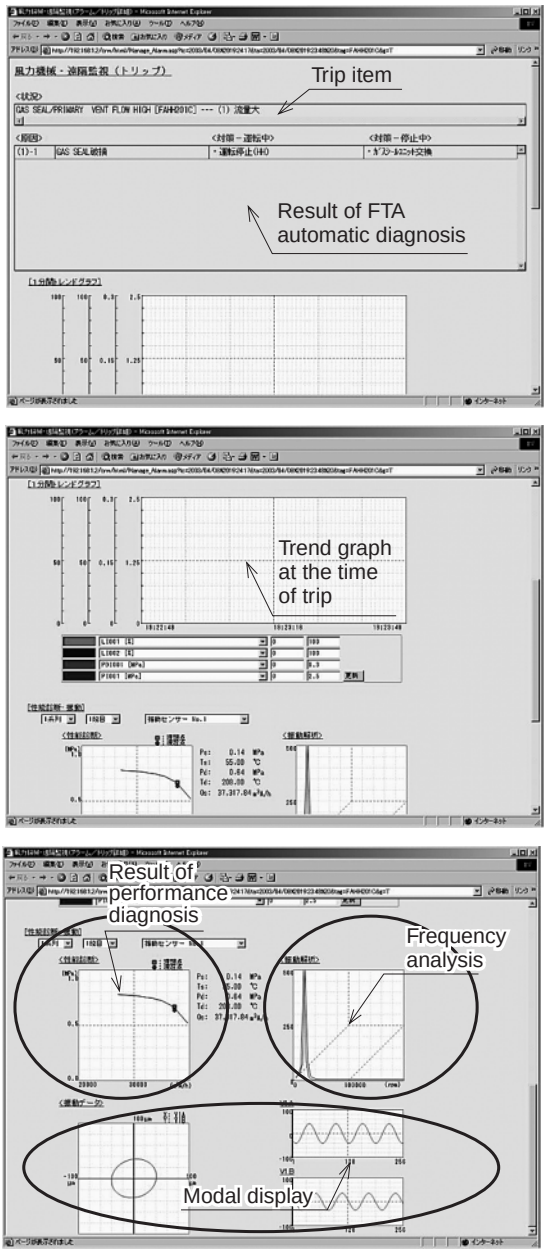


**Fig. 8 An example of the screens for vibration analysis and performance diagnosis**