

# Sensor Network for HACCP Food Safety Management

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*OVERVIEW: An increasing number of companies are incorporating HACCP practices into their food manufacturing processes in response to growing public concern about food safety and security. Monitoring is an essential part of HACCP and this article describes the features of a Hitachi wireless sensor network designed to perform this task efficiently together with a case study of its use. Hitachi's sensor network information system can perform monitoring of food production and distribution in real time with no loss of data and its features include sharing of information across a network and easy installation on existing equipment using wireless communications.*

## INTRODUCTION

AS its name suggests, HACCP (hazard analysis critical control point) combines the concepts of hazard analysis and critical control points. Unlike past approaches to food safety management that depended in a large part on experience, HACCP combines analysis of the hazards in each process from acceptance of raw materials through to production and shipping with continuous monitoring and recording of the critical control points to prevent these hazards from occurring<sup>(1)</sup>.

The adoption of HACCP at food production sites in Japan gained momentum after partial amendments to the Food Sanitation Law in May 1996 established an approvals regime for comprehensive sanitation controlled manufacturing processes that incorporates HACCP. As of the end of March 2010, approval has been granted to a total of 564 food processing facilities in Japan<sup>(2)</sup>.

12 steps have been defined stipulating how to go about introducing HACCP-based food safety management to ensure it operates efficiently and effectively. Step 8 involves setting objective management criteria, step 9 specifies how to go about monitoring, and step 12 specifies the recording and storage of the monitoring results.

Requirements included that the monitoring system be able to highlight immediately any deviation of measurements outside the management criteria and that the frequency of measurement be adequate to prevent the hazard from occurring<sup>(3)</sup>.

Whereas typical techniques used in the past for monitoring food safety at food production sites included periodic manual measurements or sensors equipped with their own memory such as temperature loggers, the amount of work needed to comply with

the criteria stipulated by HACCP was large enough to create a need for new systems.

Also because installing new sensor systems at existing food production sites or warehouses required the laying of cables, it tended to take a long time and be expensive.

On the other hand, as well as being a tool for the application of HACCP to food safety management, there are also other forward-looking requirements including playing a role as part of a strategy for differentiating companies from their competitors by helping with improvements such as better product quality and reliability. Accordingly, it is important that management and administration departments, production departments, and quality assurance departments share monitoring data and put it to strategic use.



*Fig. 1—Wireless Sensor Node.*

*In addition to incorporating a battery and temperature and humidity sensors, the compact unit [69 mm (height) × 69 mm (width) × 33.8 mm (depth)] can also be used to connect external sensors.*

## FEATURES OF HITACHI'S SENSOR NETWORK

As described above, the three key challenges associated with introducing sensor systems for HACCP are: (1) timeliness of data and reliability of records, (2) ease of system development and installation, and (3) inter-departmental sharing and strategic use of information. The following sections describe the features of Hitachi's sensor network information system for food safety monitoring in terms of how they meet these challenges.

### Real-time Monitoring with No Loss of Data

Hitachi's sensor network information system consists of wireless sensor nodes, wireless repeaters, wireless base stations, and monitoring servers and software. Because the wireless sensor nodes combine sensors with wireless communications, they can activate at fixed time intervals and send data to a server. Although the three standard types of sensors are for temperature, humidity, and particles (dust suspended in the air), data can be collected from any sensor with an appropriate output interface. Fig. 1 shows a picture of a wireless sensor node.

Each wireless sensor node can be independently configured with parameters such as measurement interval and management criteria thresholds. Similarly, an alarm can be output immediately if the data being monitored go outside the permitted range. Alarm notification can be performed by displaying the alarm on a supervisory screen or by using it to trigger the sending of e-mail or the illumination of a warning light.

The wireless sensor nodes include their own memory and have a function (backup transmission function) for automatically resending the data if it is not stored on the server for some reason. This achieves

the HACCP requirement of ensuring that monitoring data is recorded without any loss of data.

### Simple Wireless Installation

Because the sensor nodes are battery-powered and use wireless data transmission, they do not require LAN (local area network), power, or other special cabling. The very long four-year battery life (when measurements are performed at 10-minute intervals) also minimizes maintenance. Because the wireless sensor node monitors how much battery power is remaining, it can send a warning to the administrator before the battery goes flat.

Similarly, because the wireless sensor nodes detect their parent device and configure their data transmission path automatically, adding new nodes or moving existing ones is easy.

The wireless sensor nodes have a line-of-sight communications range of 70 to 100 m. However, ensuring line-of-sight can be difficult in a factory environment. However, because wireless repeaters are available to provide multi-hop wireless links in such cases, networks can be configured without needing to lay cable even in very large plants.

### Network-based Information Sharing Function

Monitoring data is stored on a server where it can be displayed in various different formats such as maps, graphs, or tables. Fig. 2 shows example monitor screens.

The data on the server can be referenced from PCs (personal computers) connected to the network. In addition to being displayed as shown above, the data can be output as CSV (comma separated value) files for analysis in other software packages.

Hitachi's sensor network information system can also generate daily reports automatically from the

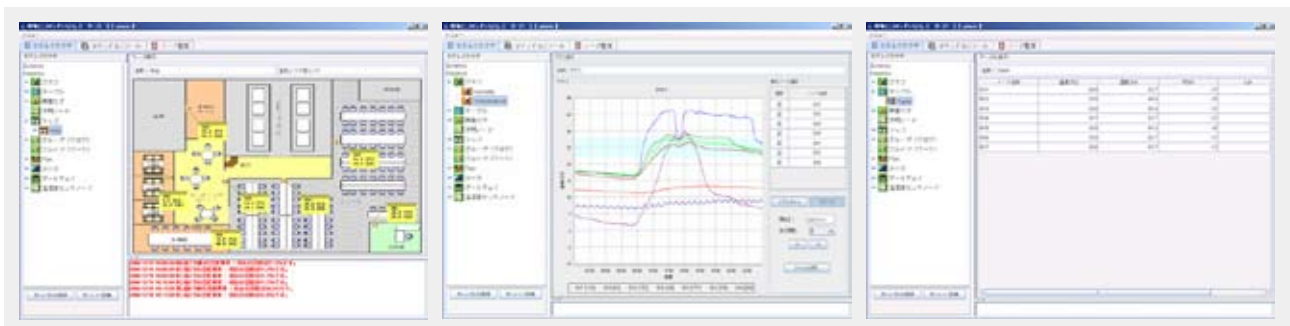


Fig. 2—Example Monitor Screens.

The latest sensor data can be displayed superposed on the plant layout or in automatically generated graphs, tables, or other formats.

monitoring data. This provides an efficient way for the administrator to review the data and undertake investigation or analysis as soon as any problems are found.

This allows the data to be turned into a competitive advantage for the manufacturing plant by cross-referencing HACCP data with quality and customer claims information using these networking and monitoring functions.

## SENSOR NETWORK CONFIGURATION TECHNOLOGY

### Sensor Network Information System Functions

The wireless sensor nodes are available in two different forms. One has its own built-in sensors and the other is designed for connecting to separate off-the-shelf sensors. Wireless sensor nodes with built-in sensors include temperature and humidity sensors and light intensity meters. The general-purpose interfaces for connecting off-the-shelf sensors include pulse input, 4-20 mA, and RS-485. These interfaces can be used to connect a range of different devices such as electric power meters, calorimeters, and CO<sub>2</sub> (carbon dioxide) sensors. Sites that require the collection of detailed information about temperature and humidity at different points on the factory floor can deploy large numbers of these wireless sensor nodes. Similarly, wireless sensor nodes equipped with general-purpose

interfaces can be used to collect sensor information from operating production lines. An appropriate combination of these different types of wireless sensor node can efficiently obtain a picture of the situation in the plant.

### Sensor Network Management Software

Hitachi supplies sensor network management software for managing the data collected using the wireless network, wireless sensor nodes, and other system components. The main functions are as follows.

- (1) Management of wireless network
- (2) Data measurement, management of measurement data, graphical display, browser display, daily report output
- (3) Fault detection, automatic recovery of data lost due to wireless communication or other faults
- (4) API (application programming interface) for interfacing with higher level systems

### Interoperation with Other Systems

In large food safety management systems such as those used in factories, Hitachi's wireless sensor network information system may be used as part of a larger factory-wide system. In this case, instead of using Hitachi's sensor network management software, the wireless equipment provided by the

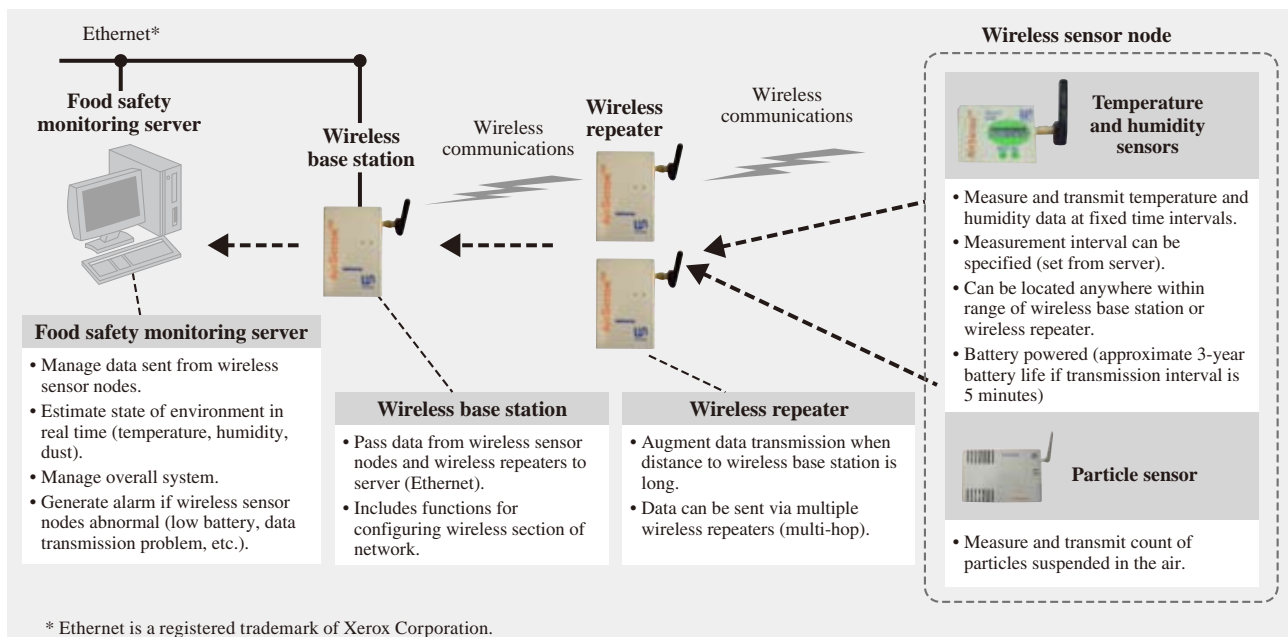


Fig. 3—Block Diagram of Food Safety Management System.

This environmental monitoring system was installed at a food manufacturing plant in Japan. The system included approximately 60 temperature and humidity sensors as well as particle sensors, wireless repeaters, wireless base stations, and a food safety monitoring server.

sensor network information system can instead be connected directly to the control devices of the energy management system. The wireless base stations store the measurement data sent from the wireless sensor nodes which means the upper level control devices simply need to read this measurement data. The three available interfaces for connecting between the wireless base stations and control devices are Ethernet, RS-232C, and RS-485.

### EXAMPLE IMPLEMENTATION OF FOOD SAFETY MANAGEMENT

Hitachi installed a system for measuring particles (dust), temperature, and humidity via a wireless sensor network and performing food safety management at a food manufacturing plant in Japan. The plant produced and marketed confectionery. The system included approximately 60 temperature and humidity sensors as well as particle sensors, wireless repeaters, wireless base stations, and a food safety monitoring server. Fig. 3 shows a block diagram of the system.

The objectives for installing the system included making food safety management more efficient and improving the level of management. A major feature of the system was that it included particle sensors as well as conventional temperature and humidity monitoring. Because these three environmental variables could be monitored in real time, countermeasures such as adjusting the flow rate, temperature, and humidity of the air conditioning could be used to restore the environment inside the plant if any of the values moved outside the permitted control range.

All of the wireless repeaters fitted when the system was installed were located inside the ceiling. This was done for hygiene reasons to prevent dust from accumulating on wireless repeaters located close to the production line.

Flour is one of the materials used at the plant and installation of the system confirmed that a rapid increase in the number of particles suspended in the air occurs during mixing of flour which prompted the introduction of measures to minimize the growth of bacteria<sup>(4)</sup>.

The system is suitable not only for food manufacturing plants but also distribution warehouses. One of the major companies in the field of frozen goods distribution, and particularly the storage of chilled and frozen goods, has introduced the system. The company operates a warehouse that features multiple storage spaces kept at different temperatures, mainly in the chilled range. To complement its existing fixed-wire



Fig. 4—Sensor Network Information System in Use. Hitachi's sensor network management software allows users to review all of the temperature and humidity data from the warehouse from an office PC (personal computer).

sensors installed at 88 locations around the warehouse, the company added 32 Hitachi wireless sensor nodes in order to provide more detailed temperature and humidity measurements than before. Through its use at the center to supply merchants with data from the Hitachi sensor network information system, the project is also winning the trust of the customer. Fig. 4 shows a photograph of the system in use at the center.

Reducing the environmental burden has become an issue for corporate management in recent years. To support the achievement of energy efficiency by making environmental information more visible, Hitachi has extended the range of wireless sensor nodes available for its sensor network information

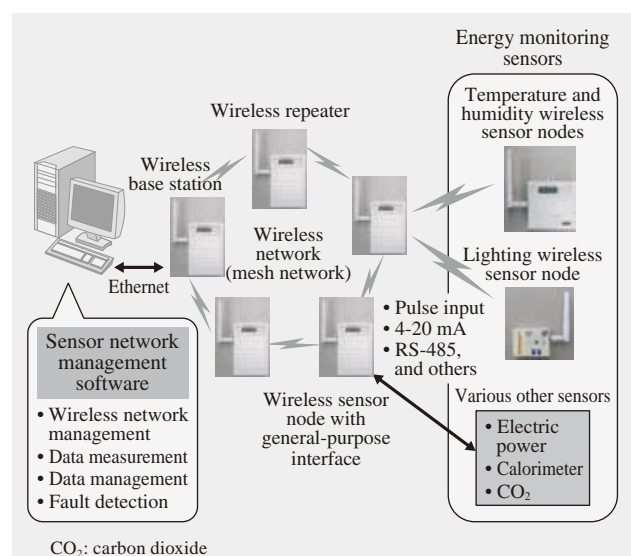


Fig. 5—Application to Energy Monitoring. The system can incorporate the external sensors required for energy efficiency.



system beyond temperature and humidity measurement to also include models with lighting and electric power measurement functions. Fig. 5 shows an example configuration for a sensor network information system that includes energy monitoring.

## CONCLUSIONS

This article has described the features of a Hitachi wireless sensor network for performing the monitoring required by HACCP efficiently and an application case study of the sensor network information system.

The need for food safety management is not restricted to food manufacturing only and is applicable in a wide range of areas including logistics, retail distribution, and food preparation in the hospitality business. It is also a field with strong requirements for safety and secure feeling.

Hitachi intends to continue promoting the development and supply of sensor networks which form part of the information infrastructure to help provide food safety and peace of mind.

## REFERENCES

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