Feature Article

Continuous Monitoring of Water Supply Using the HORIBA TW-100 Automatic Water Quality Analyzer and Remote Monitoring Systems

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In accordance with amendments to the Water Supply Law in April 2002, private enterprises could access to the operations and management of water supply and sewage facilities in Japan. Installation of the continuous monitoring equipment is increasing for efficient operations. This is the background to the development of an automatic water quality monitoring unit which would permit remote monitoring, a joint project by HORIBA and Japanese water supply and sewage management company, Nihon Hels Corporation.The TW-100 automatic water quality analyzer carries out continuous, simultaneous monitoring of 7 parameters: free residual chlorine concentration, turbidity, color, water pressure, pH, conductivity, and water temperature.See below for further details regarding the TW-100's principles of measurement, features, and results of continuous performance monitoring.

Introduction

In accordance with amendments to the Water Supply Law in April 2002, it has now become possible in Japan for certain aspects of the operation and management of public water supply facilities to be handed over to private contractors, even to the extent of comprehensive outsourcing of operations, extending from project planning through to operation and management. Installation of automatic measuring equipment is becoming an increasingly frequent way to improve efficiency in operations and management. Japanese water supply and sewage management company Nihon Hels Industry Corp. has therefore developed "MIZUMORI", a remote monitoring system for monitoring tap-water quality (Figure 1), incorporating HORIBA's water quality monitoring unit, the TW-100 Automatic Water Quality Analyzer. This system monitors tap-water quality in real time, permitting prompt detection of abnormalities in water quality or equipment, and providing a picture of water quality.

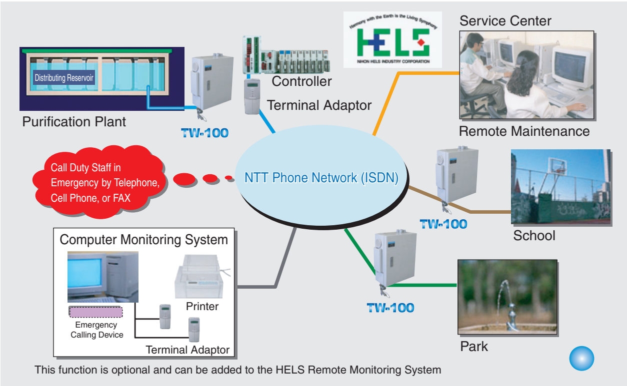

Figure 1 Diagram of Remote Water Supply Monitoring System ("MIZUMORI", Nihon Hels Industry)

Outline of TW-100

The TW-100 Automatic Water Quality Analyzer allows simultaneous and continuous monitoring of up to 7 parameters: free residual chlorine concentration, turbidity, color, water pressure as a standard feature, pH, conductivity, and in addition, water temperature. The unit was developed for ease of use in the field, and much thought was given to making it easy to maintain.

Principles of Measurement

Polarography, non-reagent method, is used to measure free residual chlorine*1 concentration. Polarography is the general term for methods which investigate the relation between the electric current and the electric voltage between two sets of electrodes in an electrolyte solution. In this case, the current value between electrodes is measured as reduction of free residual chlorine occurs on the electrode surfaces. This current is called the diffusion current, because the diffusion process of the reduced substance limits the reaction rate. The current value of the diffusion current is proportional to free residual chlorine concentration.

*1: In Japan, in accordance with the Water Supply Law, chlorine or combined chlorine are used to disinfect water, and water at the tap is required to maintain certain levels of available chlorine (residual chlorine). Chlorine is used in the following forms: liquid chlorine, sodium hypochlorite, and bleaching powder (calcium hypochlorite); while combined chlorines used include chloramine (a generic term for chemical compounds in which Cl replaces the H in NH_3 (ammonia), and monochloramine (NH_2Cl)).Equilibrium in liquids with low levels of chlorine is maintained through the existence of chlorine (Cl_2), hypochlorous acid (HClO), hypochlorite ion (ClO^-), depending on pH. Chlorine existing in water in these forms is free residual chlorine, is oxidative, and retains its disinfecting powers. Further, the chlorine in water reacts with ammonia, generating chloramines. Residual chlorine in the form of chloramine is known as combined residual chlorine[1].

Turbidity

Light absorbance is measured in order to determine the level of turbidity (how clear the water is). The particles responsible for turbidity reflect or scatter the light, and so, measuring the intensity of the transmitted light permits us to calculate the ratio of source light to transmitted light. In accordance with the Lambert-Beer Law, this logarithm (absorbance) is proportional to the depth of the water layer, and to the density (turbidity) of the suspended particulate material responsible for turbidity. This proportional relationship allows us to measure turbidity by measuring the absorbance. Measurements are carried out at a wavelength of 660 nm*2, in order to avoid interference caused by color.

*2: The color components of natural water are mostly decaying plant material (humic material: final products of breakdown when plants etc are broken down by microbes. These consist of persistent polymers - straight-chain hydrocarbons and polyaromatic hydrocarbons (PAHs) with molecular weights of several thousand to around ten thousand). Maximum absorption by these elements occurs at 360 nm and below for the ultraviolet region, and almost no absorption occurs at 600 nm or above. Therefore, the effect of water color can be ignored for measurements taken at wavelengths of 600 nm or above[1].

Water Color

Measurement of the extent of water coloration is also uses the light absorbance. Light absorbance is measured at wavelength 390 nm, to determine the color of dissolved material contained in the water, and the yellowish or tan-colors characteristic of colloidal material.

pH

pH is determined using the glass electrode method. The glass electrode method involves inserting a glass electrode and a reference electrode*3 into the sample water, and measuring the difference in potential (voltage) between the two electrodes in order to calculate pH. The TW-100 Analyzer has two junctions (liquid channels) which provide electrical conduction between the reference electrode and the sample water. Cell channels are designed to prevent air bubbles from adhering and creating electrical insulation between the reference electrode and the sample water. Further, the liquid inside the glass electrode is in gel form, removing the need to replenish the liquid inside. The channel liquid selected is particularly suited to tap-water measurement, minimizing the risk of misreadings.

*3: The electrode consists of a glass membrane which provides the pH response, highly insulating support tubes for support, internal liquid which fills the glass electrode, and a monopolar electrode in the internal liquid. Voltage potential difference is generated at the pH-sensitive glass membrane, corresponding to the pH of the solution.

Conductivity

Conductivity is measured using the alternating dipolar method. This method is used to calculate conductivity by measuring electrical resistance. Resistance is measured by applying alternating current of a specified voltage to an electrode cell with opposing electrode plates 1 cm^2 in cross-section and 1cm apart, immersed in the sample water.

Water Temperature

A thermistor thermometer is used to measure temperature. NTC[*4] thermistor is used as the resistive element, and achieves precision of ±0.5 K or better.

*4: NTC (Negative Temperature Coefficient). A type of resistive element in which resistance decreases continuously as temperature rises.

Pressure

Water pressure is measured using a semiconductor sensor. The life of the sensor is prolonged by the fact that the sensor does not come into contact with the smple water.

Structure of the TW-100

As Figure 2 shows, the unit comprises a water pressure sensor, water temperature sensor, turbidity/water color sensor, free residual chlorine sensor, conductivity sensor, pH sensor; each compact subunit with its own removable cell. The unit provides considerable freedom in the selection of measuring items, and superior maintenance features. The use of a light reflecting structure for the turbidity/water color sensor permits a cell length of 100mm, despite the compact design of the unit. This permits more sensitive measurement of turbidity and water color.

The display area consists of a touch panel LCD graphic panel, for ease of use.

Main specifications are shown in Table 1 and Table 2.

TW-100 Performance

Results of Field Tests are given in Figure 3. It is worth

Table 1 TW-100 Main Specifications

Product	Automatic Water Quality Analyzer
Model	TW-100
Measuring Items	Standard: free residual chlorine concentration, turbidity, color, water pressure Optional: pH, conductivity, and water temperature * For tap-water where measuring item values do not exceed the ranges specified by Water Supply Testing Law.
Measuring Methods	See Table 2
Measuring Ranges	See Table 2
Repeat Accuracy	See Table 2

Table 2 TW-100 Principles of Measurement, Ranges, Repeat Accuracy and Calibration

Measuring Item	Measuring Method	Measuring Range	Repeat Accuracy	Calibration
Turbidity	Light absorbance method	0-2 degree[*1] 0-4 degree	Full scale ±2.5%	Polyethylene latex standard solution (Kaolin standard solution is available.)
Color	Light absorbance method	0-10 degree[*2] 0-20 degree	Full scale ±5.0%	Color standard solution
Residual Chlorine	Polagraphy mthod	0-2 mg/L	Full scale ±2.5%	DPD colorimetric method[*3]
Water Pressure	Semiconductor detector method	0-1 MPa	Full scale ±1.0%	Standard pressure gauge
pH	Glass electrode method	2-12 pH	±0.1 pH	Standard solutions of pH 7 and 9
Conductivity	Alternating dipolar method	0-50 mS/m	Full scale ±2.0%	KCl standard solution
Temperature	Thermistor method	0-50 ˚C	±0.5 ˚C	Standard thermometer

*1: Turbidity 1 degree, equivalent to the turbidity produced by 1 mg of standard kaolin in 1 liter of purified water.

*2: Color 1 degree, equivalent to the color produced by 1 mg platinum contained in potassium chloroplatinate, plus 0.5 mg cobalt contained in cobalt chloride, dissolved in 1 liter of purified water.

*3: Residual chlorine reacts with Diethyl-p-phenyleneDiamine (DPD) to produce a pink or carmine color. This method is used to measure residual chlorine, by comparing coloration with a standard colored liquid.

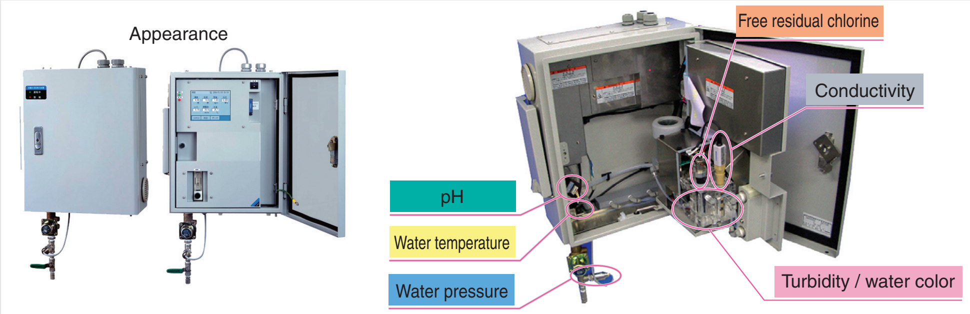

Figure 2 Structure of the TW-100 Unit

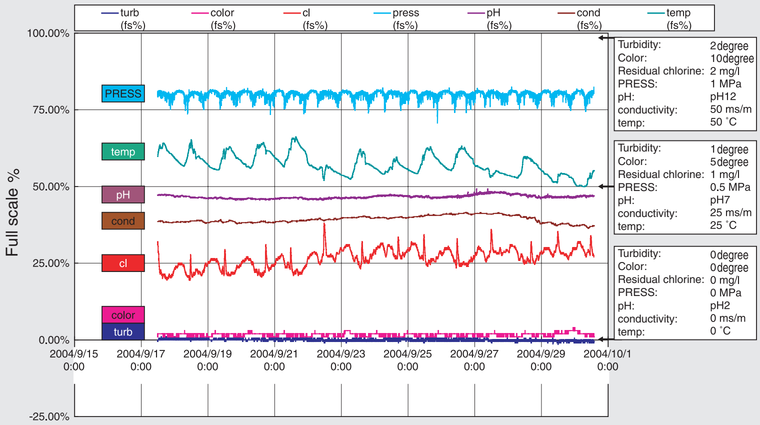

Figure 3 Continuous Monitoring Data from a TW-100 Unit in Actual Use

noting that diurnal fluctuations occur in free residual chlorine and water pressure. Free residual chlorine levels in tap-water was thought to be fairly stable, but in fact, it has been found that levels vary considerably according to the time of day, and local usage conditions. This diurnal variation in free residual chlorine values shows how very effective continuous monitoring is.

Conclusion

Japanese people are increasingly concerned about safety and reliability. This places increasing emphasis on the rule of measuring equipment. The TW-100 Automatic Water Quality Analyzer is the result of HORIBA's long years of experience with sensor technology. In combination with Nihon Hels Industry Corporation's MIZUMORI remote monitoring system, we hope the Analyzer will be installed throughout Japan in water purification plants, water distribution plants, and at the endpoints of water feedlines, providing 24-hour monitoring on a regional scale. We anticipate that this contribution to safe and reliable tap-water supply will support national safety, reliability, and health.

Reference

[1] Japan Water Works Association, Water Supply Testing Methods Explanatory Material, 1993 edition.

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