Featured Articles

Work on Introduction of Water Distribution Control System in Zhejiang Province, China through Public-private Partnership

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OVERVIEW: Hitachi has undertaken a feasibility study whereby it has participated in a model public-private partnership for the adoption of a water distribution control system already proven through use in Japan by a selected water utility in Zhejiang Province, China. The region covered by the study has a total customer base of 150,000 people with maximum demand of 30,000 m³/day. Based on the results of an on-site survey of the water distribution network and other infrastructure, an investigation was conducted into future problems with low pressure in the distribution network due to increased water demand. The study found that, by formulating a pipe network plan that makes maximum use of the gravity-fed distribution of water from treatment plants, and by undertaking the basic design of the water distribution control system with this plan as one of the design assumptions, it should be possible to achieve a reliable supply of water and the efficient operation of infrastructure. Based on this experience, Hitachi intends to continue contributing to the international deployment of Japanese water technology.

INTRODUCTION

THIS article describes an example of the public and private sectors in Japan working together on the international expansion of the water industry that involves work being undertaken in China in support of the management of water distribution by small and medium-sized utilities.

In line with the Chinese government's intention to improve the overall standard of water supplies, a memorandum of understanding was reached between Japan's Ministry of Health, Labour and Welfare and the Ministry of Housing and Urban-Rural Development of the People's Republic of China in May 2008 regarding technical collaboration with Japan on water supply in regional Chinese cities. Based on this agreement, a regional city in Zhejiang Province, China was selected by the Ministry of Housing and Urban-Rural Development to participate in the project. An on-site survey and consultations were held with the main urban water utility in the city in November 2008. This led to a model project that primarily involved support for the management of water distribution in cooperation with a utility that expressed a desire to adopt Japanese technology. The agreement to undertake this project was signed in November 2010.

As regional cities along the Pacific coast of China have been experiencing remarkable economic growth and rising water demand, there is a high level of concern about improving the efficiency of water distribution management and maintaining the reliability of water supplies. To utilize Japanese technology as part of efforts to help overcome these challenges, we proposed a plan for pipe network optimization and prepared a basic design for the installation of a water distribution control system based on a survey of the participating local water utilities. The following sections provide an overview of this work.

SURVEY METHOD

Three preliminary surveys of the participating region were conducted from November 2008 to February 2010 through collaboration between relevant agencies in China and the Water Supply Division at the Health Service Bureau, Ministry of Health, Labour and Welfare and other public and private sector agencies in Japan[1], [2] (see Table 1). Through this process, the participating water utility was selected and work

TABLE 1. Preliminary Survey and Full Survey of Participating Region

Surveys and consultancy were undertaken as a public-private partnership with the aim of introducing Japanese water supply technology to regional cities in China.

Item	Date	Survey work	Remarks
Preliminary survey 1	November 2008	Consultation with candidate utilities in the selected regions	Project for International Expansion of the Water Industry, Water Supply Division at the Health Service Bureau, Ministry of Health, Labour and Welfare
Preliminary survey 2	November 2009	Presentation of information about Japanese products and technologies to candidate utilities in the selected regions.	Same as above
Preliminary survey 3	February 2010	Agreement among relevant parties to commence model project for water distribution management at selected participating utility.	Same as above
Full survey 1	June 2010	Preliminary survey of treatment plants, pumping stations, and other infrastructure at participating utility	In-house survey
Full survey 2	August 2010	Detailed survey of treatment plants, pumping stations, and distribution pipe networks at participating utility	Water Saving and Environmentally-friendly* Water Recycling Project of NEDO
Full survey 3	October to November 2010	Additional survey of water treatment plants, pumping stations, water distribution network; relevant parties from Japan and China agree on memorandum of understanding for conducting model project.	Same as above*
Full survey 4	April 2011	Detailed survey of water treatment equipment	In-house survey

NEDO: New Energy and Industrial Technology Development Organization

* Water Saving and Environmentally-friendly Water Recycling Project, Research and Development of Water Resource Management Technologies, Demonstration Research aimed at their Deployment in Japan and Overseas, Verification and Feasibility Study of Work on Supporting Energy-efficient Water Distribution Management in Asia (Phase 1) of NEDO

started on the model project for water distribution management, with the districts supplied by the utilities used as the model region.

Since June 2010, with assistance from the New Energy and Industrial Technology Development Organization (NEDO), two full surveys of the water distribution networks and other infrastructure in the model region and two independent surveys to collate the challenges facing water distribution management, now and in the future, have been conducted. Additionally an investigation has been conducted into the best ways to make improvements in response to predicted future increases in water demand(3).

Table 2 profiles the water utility selected for participation in the model project. Although small, the operation of the utility is typical of regional cities, providing 24-hour water supplies with approximately 15% of non-revenue water ratio. However, because the region is experiencing rapid economic growth, increasing demand has been causing problems with low water pressure at the edge of the network. To overcome these, it was decided to assist the utility with a two-stage draft plan involving, (1) Optimization of the water distribution network, and (2) Installation of a water distribution control system.

The surveys of the water distribution network were performed using maps of the water pipe network provided by the participating utility, and a field survey of the entire model region to ascertain conditions on the ground. The pipe network analysis function of Hitachi's geographic information system (GIS) based water distribution management system was used to perform pipe network simulations based on the data obtained by the surveys.

On-site surveys were also conducted to obtain information about the water treatment plants and distribution pumping stations, including equipment configurations and operating conditions.

TABLE 2. Profile of Participating Utility

A regional city in Zhejiang Province, China that is experiencing rapid economic growth.

Item	Value	(As of 2010)
Customer base	150,000	people
Supplied area (model region)	300	km^2
Maximum daily water supply (present day)	15,000 (approx.)	m^3/day
Maximum daily water supply (future)	30,000 (approx.)	m^3/day
Treatment capacity (future)	30,000 (20,000 at treatment plant A, 10,000 at treatment plant B)	m^3/day

OPTIMAL PLANNING FOR WATER DISTRIBUTION NETWORK

In addition to collating information about the challenges facing water distribution networks now and in the future, an investigation was also conducted into a plan for optimizing the distribution network to cope with predicted future increases in water demand.

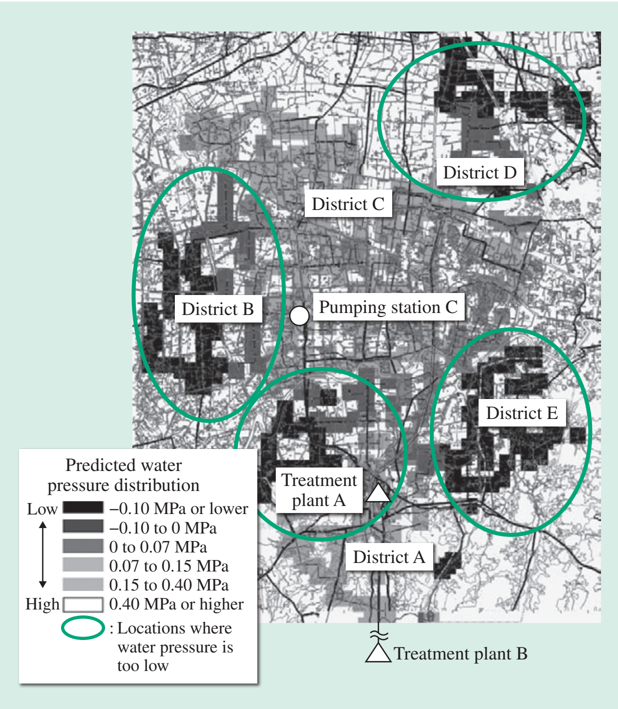

Fig. 1—Water Pressure Distribution and Future Predictions for Model Region.
Pressure shortfalls due to increases in water demand anywhere in the covered regions were predicted based on the use of the distribution network analysis function in Hitachi's geographic information system (GIS) based water distribution management system to simulate the future distribution of water pressure in the pipe network.

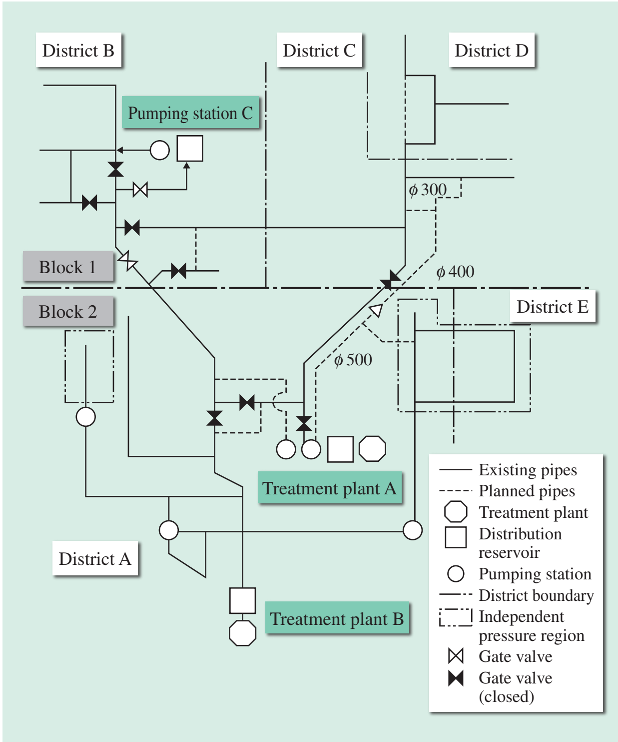

Fig. 2—Optimal Planning for Water Distribution Networks.
A plan that considers both cost reduction and energy efficiency was formulated for optimizing the pipe network to deal with future problems of low water pressure by preventing the water supplies from treatment plants A and B from interfering with each other.

Understanding Present and Future Challenges Facing Water Distribution Networks

Apart from a mountainous area in the south, the model region (districts supplied with water by the participating utility) is largely flat. As of April 2011, water distribution to the entire district A, located in the center of the model region, was supplied by pumping from treatment plant A, which is located in the middle of the district. At this time, treatment plant B located in the mountainous area in the south of district A (from which water distribution is gravity-fed) and pumping station C in the nearby district B were both out of service, future plans are based on the assumption that these will resume operation.

A water pressure simulation was performed based on the collected data for the entire water pipe network in the model region. This indicated that, given the current maximum capacity of approximately 15,000 m^3/day, low pressure (less than 0.15 MPa) would occur in districts D and E at the edge of the network, a result consistent with the routine water distribution management conditions for the participating utility.

The simulation also predicted low pressures would occur throughout the model region in the future, when water demand is forecast to increase to approximately 30,000 m^3/day (see Fig. 1). This found that, even with treatment plants A and B both operating, gravity-fed distribution from treatment plant B would be inadequate due to the water supplies from the two plants interfering with each other.

Based on these results, an investigation was conducted into planning how to optimize the distribution network to overcome these problems.

Investigation into Distribution Network Optimization Plan

To reduce the cost of improvements and encourage energy efficiency, the planning process adopted a policy of avoiding the installation of any additional pumps as much as possible. Specifically, what this meant was to use improvements to the distribution network as the primary way of ensuring adequate pressure, while also seeking to reduce energy use by making maximum use of gravity-fed water distribution from treatment plant B in the mountainous area.

Fig. 2 shows an overview of the plan. The investigation concluded that, in addition to ensuring adequate pressure throughout the model region by dividing the pipe network into blocks (as described below) and other measures based around improving the pipe network, efficient water distribution could be achieved by making maximum use of gravity-fed water distribution.

Division of Pipe Network into Blocks

To eliminate problems such as interference between water distribution from the two treatment plants as much as possible and take maximum advantage of gravity-fed distribution, the network was divided into blocks, with districts A and E in one block and districts B, C, and D in the other. Under this arrangement, gravity-fed distribution from treatment plant B would supply districts A and E and pumped distribution from treatment plant A would supply districts B, C, and D.

Pipe Network Improvements

The on-site survey found that parts of the distribution network at the network edge had a tree and branch structure, leading to concerns about such problems as retention of water in the pipes and low water pressure or quality. To minimize these risks and ensure a reliable supply of water, an improvement plan was formulated whereby connections would be created between the pipelines in each system to achieve a loop topography for the edges of the network.

IMPLEMENTATION OF WATER DISTRIBUTION CONTROL SYSTEM

Having collated the current challenges facing water operation, a draft design for implementing a water distribution control system was collated with reference to future equipment planning and based on the assumption that the above optimization of the water distribution network would proceed.

Present and Future Challenges for Water Distribution

Based on the results of the on-site survey, it was found that water distribution faces the following present and future challenges.

- Low water pressure and residual chlorine concentration in some areas
- Heavy workload due to manual plant operations (no central monitoring and control system installed)
- Problems with reliability and efficiency due to lack of communications between sites

Preparation of Draft Design for Water Distribution Control System

A draft design was produced for implementing a water distribution control system to overcome the challenges listed above.

A water distribution control system maintains adequate water pressure in the distribution network for supplying water from the treatment plants and distribution reservoirs to consumers (see Fig. 3). The system considered for this application is based on control of the network pressures by making continuous measurements of water pressure at various points around the pipe network, running realtime simulations utilizing offline data on the pipe network (such as GIS data and billing data), and using these to adjust set-points such as outlet pressure of pumps and valves opening automatically. All of the steps from pressure measurement to control adjustments would be performed automatically.

Taking account of the state of communications infrastructure at the site, it was decided to adopt a system configuration based on the use of the cellular telephone network for monitoring pipe network measurements and an optic fiber network for central

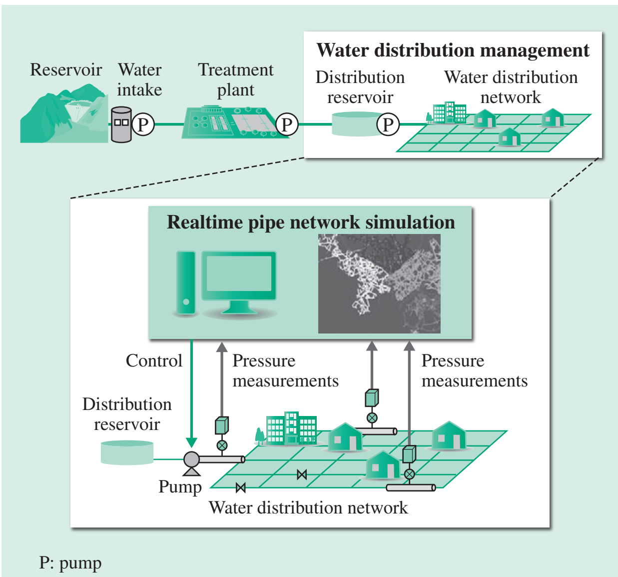

Fig. 3—Overview of Water Distribution Control System.
The diagram shows an example water distribution control system that optimizes water pressure from the treatment plants and distribution reservoirs to consumers.

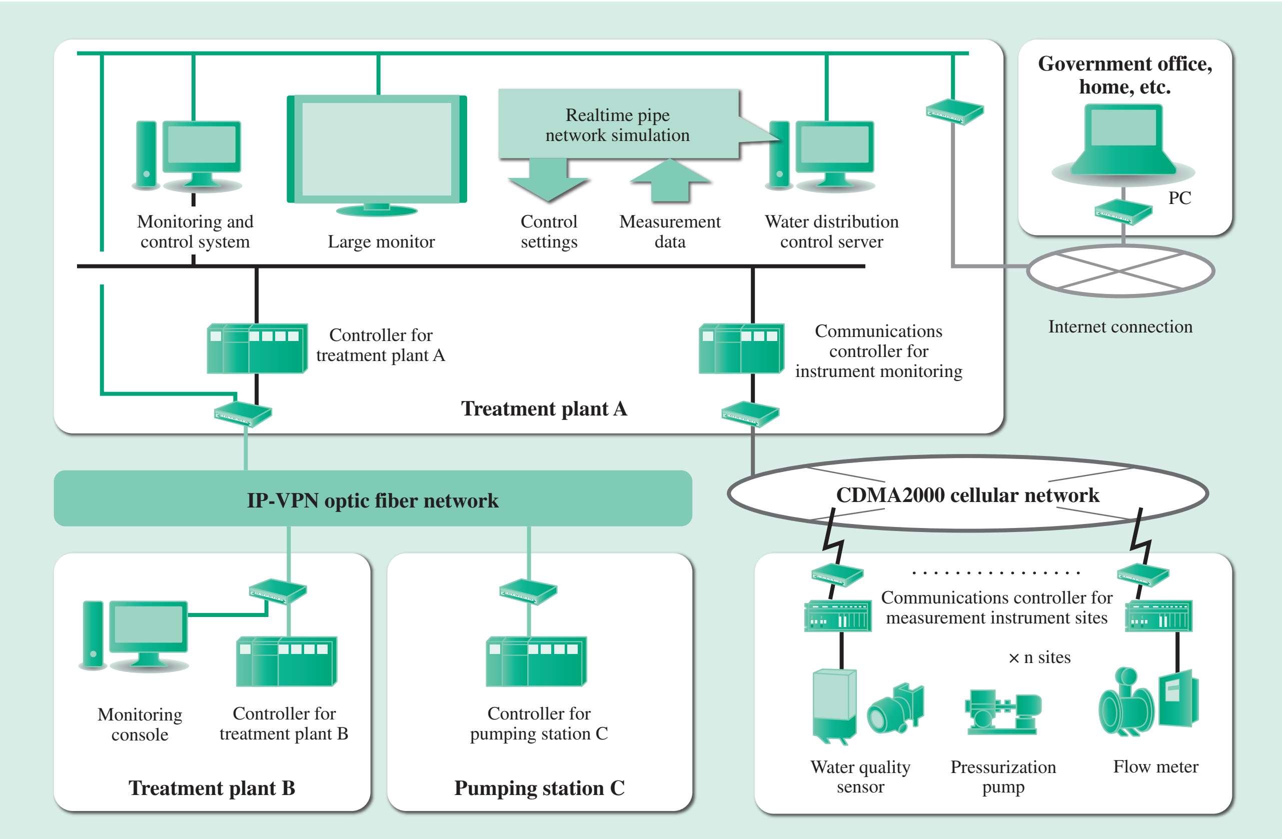

Fig. 4—Block Diagram of Water Distribution Control System.
A water distribution control system was proposed together with a plan for optimizing the water distribution network to deal with future problems due to low water pressure.

monitoring and control (see Fig. 4). Centralized monitoring should provide both productivity improvements and a faster response to abnormal situations. Along with eliminating low water pressure by coordinating the operation of treatment plant A and pumping station C, it was also anticipated that the system would provide better control in terms of energy efficiency.

Work is proceeding at the site on improving the water distribution network and adopting centralized monitoring and control of the treatment plants, with the adoption of a water distribution control system among the issues being considered.

FUTURE DEVELOPMENTS

Use of Water Distribution Control System to Save Energy

Water-related efforts presented in the 12th Five Year Plan of the Chinese government include making progress on public facilities and services, making effective use of water and energy resources, and measures for dealing with water and atmospheric pollution. The customer base for urban water supplies is growing steadily, as is the total volume of water supplied. Along with the provision of services that satisfy this rising demand for water, there is a need for systems that can make effective use of limited water and energy resources while also taking account of environmental protection, including water quality and the atmosphere.

As we estimate that 40% of the power consumed by the water industry is used by pumps for transporting or distributing water, measures for improving the energy efficiency of these pumps will provide major benefits to the industry.

Table 3 lists the primary ways of saving energy in the transportation and distribution of water. While it depends on when equipment is installed, effective methods over the medium to long term include the appropriate management of piping and other infrastructure and improvements in the efficiency of plant and equipment. On the other hand, efficiency improvements achieved through

TABLE 3. Ways of Saving Energy in Water Transportation and Distribution
Using control of overall operation to improve efficiency is an effective way to achieve better energy efficiency in a comparatively short time.

	Challenge	Ways of saving energy	Time scale	Cost	Benefits	Assessment
1	Improve efficiency through better management of pipes and other infrastructure	• Repair or replace water distribution pipes to reduce leaks	Long	Medium	Medium	○
2	Efficiency improvements to plant and equipment	• Installation of highly efficient energy-saving equipment (such as pumps) • Use of capacitors to improve power factor • Replacement of existing pipes and valves with low-resistance alternatives	Medium	High	High	○
3	Control of overall operation to improve efficiency	• Control pumps to avoid over-pressure • Detailed control of pump output based on fluctuations in demand	Short	Low	High	◎

control of overall operation can deliver benefits over a comparatively short time period just by installing control equipment, without making major changes to existing infrastructure, meaning it has a good cost/benefit ratio. The installation of a water distribution control system is one such method and it is an effective way to improve energy efficiency across the water distribution system.

Furthermore, because the system can adapt flexibly, from the planning to the design level, to changes such as predicted future increases in water demand, Hitachi believes that it is an effective option for the regional cities of China as the country becomes increasingly urbanized.

Use as Water Leak Management System

Because the water distribution control system described in this article uses realtime pipe network analysis, it can also be used as a water leak management system with realtime functions. The system has potential applications in supporting leak surveys and countermeasures by using links to asset management data on water piping to identify the risk of water leaks and estimate the likely volume. [The volume of water leaks in each district metered area (DMA) is estimated using Hitachi's proprietary classification method.]

The system also has potential for future use in places like Southeast Asia and India, where dealing with leaks from water pipes is a major challenge.

CONCLUSIONS

The initial objective of this work was the overseas expansion of the Japanese water industry(4). Based on a study of the viability of utilizing advanced Japanese technologies in a model region in China conducted through collaboration between the public and private sectors in both nations, it was concluded that the adoption of technologies for supporting pipe network planning and the installation of water distribution control systems have the potential to help improve efficiency of water distribution management and stability of supply in the regional cities of China.

In the future, Hitachi intends to evaluate and verify the markets, profitability, and so on for the systems and planning support technologies described in this article, including in the form of an ongoing integrated business that also encompasses training in operation and management. As China is seeking to improve its technology for operating water utilities as a matter of national policy, Hitachi aims to draw on experience from this work to establish business models that suit the Asian region, and to deploy them more widely.

ACKNOWLEDGMENTS

This article draws on material from the Water Saving and Environmentally-friendly Water Recycling Project of NEDO. Furthermore, the work also benefitted from advice and support from the Water Supply Division at the Health Service Bureau, Ministry of Health, Labour and Welfare; the Japan Water Works Association; the Federation of Japan Water Industries, Inc., and Pacific Consultants Co., Ltd. The authors would like to express their thanks to all of these agencies involved in the work.

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