

CONTROL SYSTEM FOR SMALL SCALE WATER AND SEWAGE WORKS

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I. FOREWORD

Viewed from the standpoint of scale, about 70% of all waterworks organizations serve a population of less than 30,000 people. Moreover, the waterworks industry is steadily moving from the age of construction to the age of maintenance and the scope of control is spreading from the water treatment plants to the water service reservoir, relay pumping station, and other facilities outside the plants. This trend is also seen in small scale water works. It is demanded that a supervisory and control system is installed to control the water treatment plants and facilities outside the plants.

On the other hand, the popularization of sewage works has reached 33% and its objective is expected to shift from large cities to the small scale enterprises of medium and small cities. Therefore, a control system suitable to small scale plants is demanded. Moreover, the construction of sewage treatment plants has been accompanied by a strengthening of water quality preservation measures, and the introduction of total contamination quantity restriction has made it necessary for facilities managers to build up their water quality control system.

A simple supervisory and control system for small scale water and sewage treatment plants such as the above is necessary from the standpoints of efficiency and cost. This report describes a small scale control system using digital instrumentation.

II. SYSTEM DESIGN CONDITIONS

Control systems for small scale water and sewage plants must be designed to match the treatment capacity and scale of the facilities based on clarification of the operating contents. This section describes the design preconditions and the conditions demanded by the system.

- (1) Since there are limits on facilities construction and maintenance expenses, the control system must have a simple configuration and must contribute to labor saving in daily operation.
- (2) The number of personnel who maintain and control the entire facility is small and manning the facility with

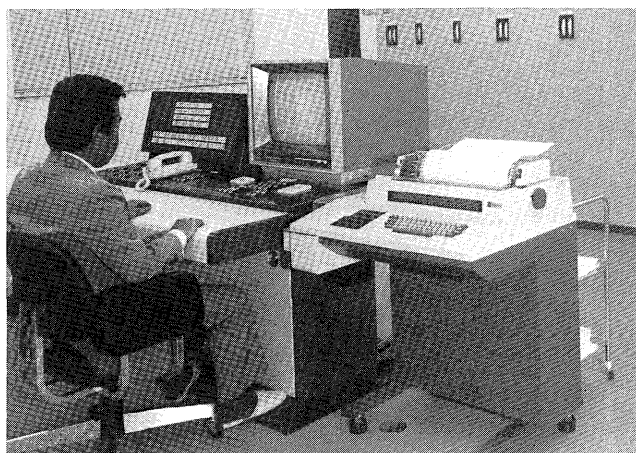
electrical, instrumentation, and mechanical engineers is difficult. Therefore, operation must be easy to understand and maintenance and inspection must be simple.

- (3) Because most consumers in the water distribution zone and users in the treatment zone are general households, and the load pattern is fixed, advanced adaptive control is unnecessary.
- (4) The objective of supervision and control is not limited to the clear water plant and treatment plant, but is expanding to include the water distribution reservoir, relay pumping station, and other facilities outside the plants. To supervise and control facilities outside the plants at a rational cost, the installation of telemetry and telecontrol equipment must also be considered.

From these basic conditions, the design conditions for control systems for small scale water and sewage plants are:

- (1) Conventional measurement items and control system which are mainly flow, water level, and water quality measurement and dosing and aeration control.
- (2) Centralization and automation of the measured values and apparatus status monitoring, display, and recording system to facilitate operation and control by a small number of personnel.
- (3) CRT display to omit indicators, recorders, etc. and simplify a mimic board for display of apparatus running status.

Fig. 1 Supervisory and control equipment



- (4) Automatic reporting by adoption of a logging type-writer and one-man control.

III. FUNCTIONS OF CONTROL SYSTEM

There are three control systems: Type A and Type B direct input type and Type C remote supervisory and control type. These systems have about the following basic functions (Figs. 2, 3, 4):

Type A: Printing function, data supervision function

Type B: Printing function, data supervision function, process control function

Type C: Printing function, data supervisory and control function, telemetry and telecontrol function

The specifications of each type of systems are given in Tables 1, 2, and 3.

Fig. 2 Type A system

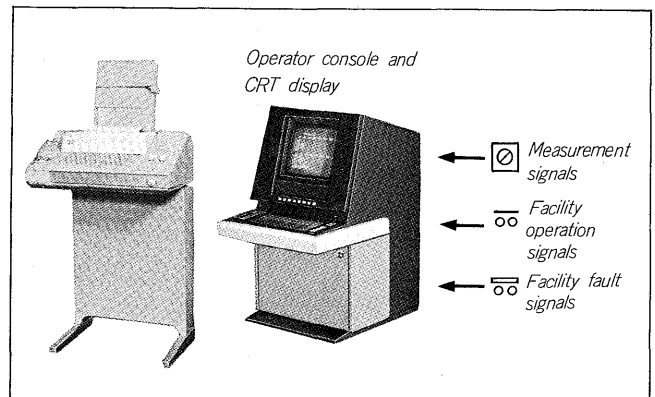


Fig. 3 Type B system

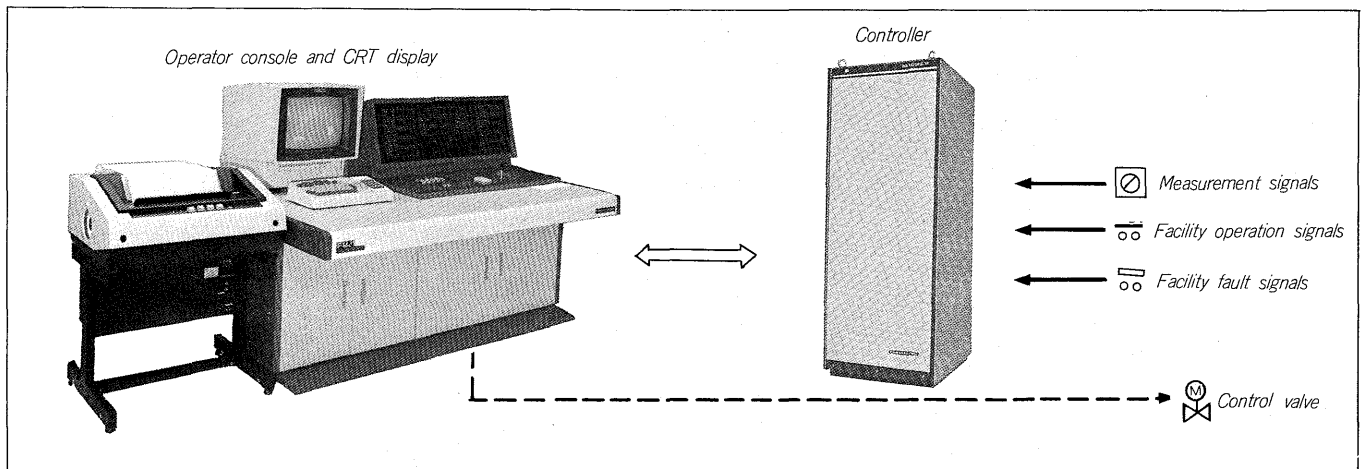


Fig. 4 Type C system

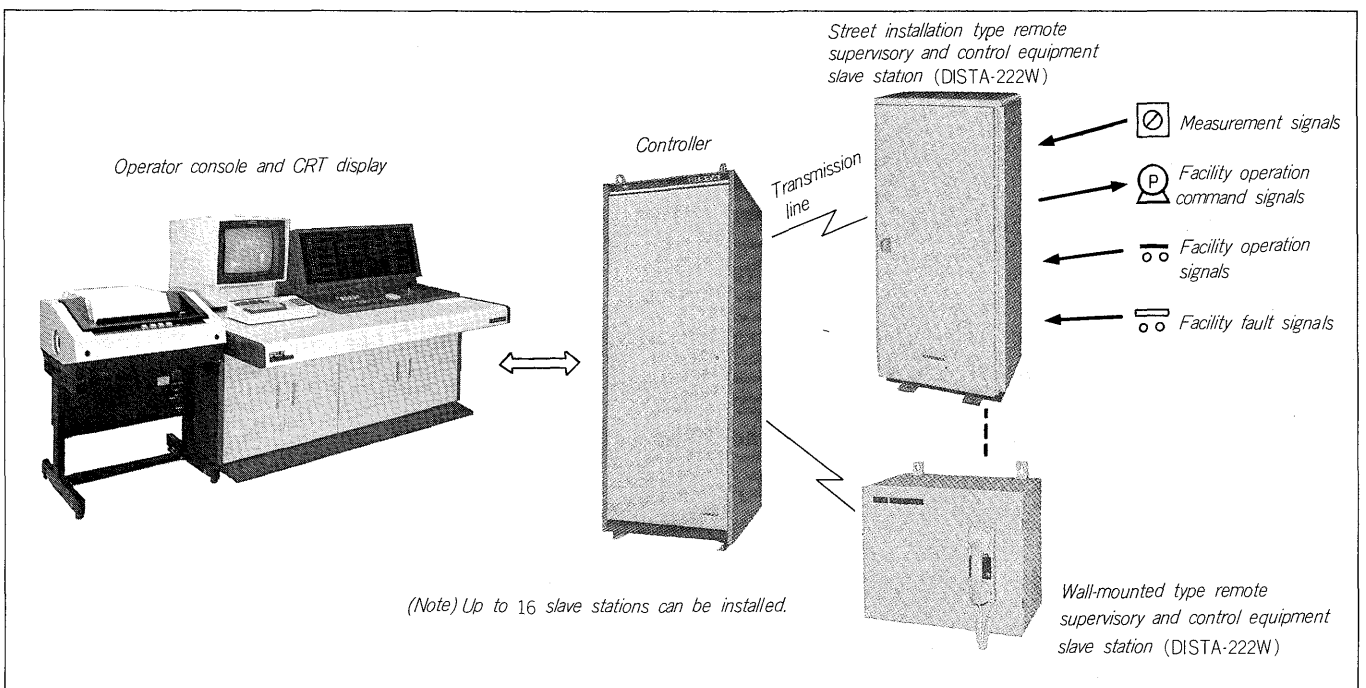


Table 1 Type A system specifications

Item		Specification		Remarks
Number of input/output channels	Measurement input (analogue)	Max. 64		
	Integrating input (pulse)			
	Integrating input (code)			
	Equipment operation, fault input (contact)	Max. 128		Used when alarms are displayed at the outside.
	Alarm output (contact)	Max. 4		
Printer	Number connectable	1		
	Report or trouble and alarm printing	Dot matrix 80 chars/line Dot matrix 136 chars/line		One selected.
CRT display	Monitor	12 inch monochrome	14 inch color	One monitor selected
	Display color	Green face	7 colors	
	Display characters	80 chars × 25 lines	640 × 400 dots	
	Character set	Letters, numbers, Kana characters, symbols, patterns 256 kinds Chinese characters, special patterns 384 kinds		

(1) Printing function

Besides hourly printing at each hour and printing of the daily summary report, facilities equipment and measured value upper and lower limit alarm printing are possible. (However, with the Type A, one is selected.)

(2) Data supervision function

The facilities operating status is displayed on a CRT display. The display screens consist of measured value screen, alarm screen, and trend display screen.

(3) Process control function

Process control is performed by single loop type digital controller.

(4) Telemetry and telecontrol functions

Supervision and control of remote water and sewage facilities is performed from the center.

IV. APPLICATION TO WATERWORKS

The processing mode of small scale waterworks can be a low processing capacity water purification plant with river water as its water source or only an intake and sterilization facility with underground water as its water source.

4.1 Small scale water purification plant

When river water as the water source is used, the water purification process is the same regardless of the scale. However, when the amount of water processed is several thousand cubic meters per day, the number of reservoirs and the number of power facilities is small and the number

Table 2 Type B system specifications

Item		Specification	Remarks	
Number of input/ output channels	Measurement input (analogue)	Total max. 128 items	} Max. 128 items	
	Integrating input (pulse)	Max. 128 items		
	Integrating input (code)	Max. 32 items (32 words)		
	Equipment operation and fault input (contact)	Max. 512 items (32 words)	} Total max. 32 words	
	Alarm output (contact)	Max. 32 items	Used when alarms are displayed at the outside.	
Typewriter	Number of type-writers connectable		Max. 3	—
	Number of printing items	Hourly report	Max. 120 items (two-stage/2 units)	Max. 30 items (one-stage/unit) Max. 60 items (two-stage/unit)
		Daily report	Max. 160 items (2 units)	Max. 80 items/unit
		Operation fault printing	Max. 512 items	Max. 32 chars/item
		Upper and lower limit alarm printing	Max. 128 items	Same as above
CRT display	Monitor		20 inch, color monitor	—
	Display color		8 colors	—
	Number of display characters		64 chars × 32 lines	—
	Character set		135 kinds	Letters, numbers, Kana characters, symbols
	Number of display screens	Facility diagram display screen	Max. 8	—
		Measured value display screen	Max. 8	—
		Alarm display screen	Max. 8	—
		Trend display screen	Max. 3	Max. 10 items

Table 3 Type C system specifications

	Item	Specification	Remarks
Transmission unit	Number of connectable slave stations	Max. 16 (DISTA-222, 1000)	2 for DISTA-1000
	Line configuration	1 : N system	—
	Transmission line	NTT D-1 standard or private line	—
	Transmission speed	200, 1200 bits/sec	—
	Transmission capacity	Measurement signal	Within max. 128 items (N station total)
		Integrating signal	
		Equipment operation fault signal	
	Control signals	DISTA-222: 30 items/slave station DISTA-1000: 100 items/slave station	The transmission capacity per station depends on the remote telemetry and telecontrol equipment slave station specifications.
	Type writer	Same as Type B system	—
	CRT display	Same as Type B system	—

Table 4 Measurement and control items at purification plant

	Measurement item	Control item
Connecting well	Water level, flow, water temperature, turbidity, pH	Raw water flow control
Sedimentation basin	(Sludge Boundary)	Flocculator control
Filtration basin	(Water level), (loss of head), flow	Filtration flow control Filtration basin washing control
Washing tank	Water level	Washing tank water level control
Clean water reservoir	Water level, flow, turbidity, residual chlorine, pH	Clean water reservoir water level control Service flow control
Dosing facility	Dosing amount, storage tank liquid level	Dosing control
Others	(Valve position)	—

(Note): Items in () are performed as required.

of measurement control loops is not that large. *Table 4* shows the general measurement and control items at a small scale purification plant. At a small scale purification, alarm detection of washing tank water level and chemical storage tank liquid level by electrode relay is sufficient, and continuous measurement is unnecessary. Moreover, when a syphon type is used at the filtration basin, head loss measurement and filtering flow control are unnecessary. Therefore, since the main function of the system is supervision, when control is not performed, simple facility supervision is possible with a Type A system. Besides, since the number of loops is about 10 to 20 even if a control function is added, control is possible with a Type B system with controller. Because the Type B and Type C systems are designed so that mixing within the total number of input and output channel restriction, if combined with telemetry and telecontrol slave stations installed at the water distribution reservoir, relay pumping station, etc., total control of the water level, flow, pump operating status, etc. not only at the purification plant but also at the outside facilities is possible together with the purification plant data. The existing control level can be substantially raised and the outside facilities patrol work burden can be lightened.

4.2 Simple water source

The purification plant with water sources of underground water or spring water which is of good water quality has only sterilization processing. In such cases, personnel assignment rationalization, operation labor saving, and effective mutual accommodation of several water sources are possible by collecting the operation data from each water source at one place by installing a telemetry and telecontrol equipment slave station at each water source.

The telemetry items are intake well and distributing reservoir water level, distributing flow and intake pump, sterilizer operation, fault signals, etc.

It is convenient if the telecontrol items are planned so that besides pump and sterilizer starting and stopping,

operation sequence setting alteration, number of operating units specification alteration, and other operation mode alteration commands utilizing the site automatic sequence are performed.

In central control of such multiple simple water sources, the need for simultaneous supervision of the entire facility is very small. Therefore, compared to total supervision by graphic display, selective supervision in plant units is superior from the standpoints of operation efficiency, installation conditions, economy, etc.

V. APPLICATION TO SEWAGE WORKS

In sewage works, the system can be applied in the following three ranges.

5.1 Application to treatment plant process

Many small scale treatment plants generally have very few basins and facility equipments. Therefore, the supervisory and control equipment can be simpler than that of conventional treatment plants and application of this control system is possible.

Since the treatment zone range is limited, the special feature from the standpoint of control is that the flow, water quality, and other processes daily changes are large. Thus, the control system must accurately supervise process changes. Moreover, for process stabilization, a digital controller must be added. Control is performed by a Type A or Type B system with the measurement items shown in *Table 5* as the supervisory objective.

5.2 Application to centralized control system for relay pumping station

This control system can be applied to a system which controls the relay pumping station for wastewater which flows into the treatment plant, from the center by using

Table 5 Measurement items at sewage treatment plant

Facility name	Measurement item	
Pumping plant	Inflow conduit water level Inflow gate position	Pump well water level Sewage water flow
First sedimentation basin	Sludge extraction amount Extracted sludge density	
Aeration tank	DO	
Blower	Air flow	
Final sedimentation basin	Return sludge amount Return sludge density Excess sludge amount	
Disinfection facility	Sodium hypochlorite dose Discharge flow	
Sludge concentration tank	Extracted sludge amount Extracted sludge density	
Dehydration facility	Sludge supply tank liquid level Sludge supply amount Chemical supply amount Sludge density	Chemical solution tank liquid level Dehydration cake storage amount

Table 6 Water quality supervision items

(1)	Water quality (COD)
(2)	Drainage flow
(3)	Pollution load amount
(4)	Pollution load amount total
(5)	Water quality meter faulty

telemetry and telecontrol equipment.

At the treatment plant, inflow sewage receiving cannot be temporarily halted or stopped. In many small scale businesses, there are many cases in which the relay pumping station is unmanned. Therefore, the relay pumping station data is properly collected and effective control is performed through the CRT. The Type C is applicable as the system.

5.3 Application to water quality pollution load control system

The data from water quality pollution load measuring devices located at each point is collected at the control center by telemeter equipment and data processing is performed by this control system. Various reports are prepared and supervision of the abnormal data applicable to pollu-

tion control is performed at the same time and the results are reported to the operator by CRT display and alarm printing.

The main control objectives are:

- (1) Supervision of the discharge water from the treatment plant to rivers.
- (2) Supervision of industrial waste which flows into the trunk sewage.

As a system, the main function is supervision, not process control. However, it is a system which catches the quality of the water flowing into the treatment plant in advance and reflects it to the treatment plant supervisory and control system. The measurement items per location are shown in Table 6.

VI. POSTSCRIPT

Since the trend in water and sewage works is toward an increase in small scale facilities, a simple control system is demanded.

The control system introduced here can be said to be a high cost-performance system applicable to small scale facilities.

Moreover, in the future, microcomputer and other advances will be incorporated and these control systems will be steadily improved.

