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COMPREHENSIVE WATER CONTROL SYSTEM IN SENOGAWA FILTRATION PLANT, HIROSHIMA PREFECTURE

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I. INTRODUCTION

In the past, the construction of waterworks facilities was mainly centered about large cities. Today the popularization rate of waterworks has reached 90%. However, recently the contents of the demanded waterworks construction has changed. Because of the trend toward an increase in the population of medium and samll cities, water supply facilities is being conducted in peripheral cities. The so-called prefecture managed waterworks correspond to this and not only provide water, but also feature management of waterworks over a fairly wide region, including water conveyance. The Hiroshima Prefecture Senogawa waterworks recently constructed is of this type. This waterworks was constructed as Hiroshima Waterworks Project, Ohtagawa Eastern Region Waterworks Phase 2 project and was placed on-line July 1, 1980. Today, expansion work is proceeding in step with construction of the Higashikaita pumping station. The comprehensive water control system, including the Higashikaita system, is introduced.

II. OUTLINE OF PLANT

The water facilities are outlined below.

Location : Senogawa, Hataga, Hiroshima City
Estimated water supply population : 730,580 persons
Estimated maximum water consumption per a day : 192,000m³/d
Estimated water quality
Service water : 100,000m³/d (Currently : 50,000m³/d)
Sedimentation water (Source water for service water, industrial water) : 450,000m³/d (Currently : 112,500m³/d)
Water facilities :Conform to Table 1.

III. FUNDAMENTAL SYSTEM POLICY

1. Basic conditions

The basic conditions inherent to the plant that were the preconditions of the system design are described below.

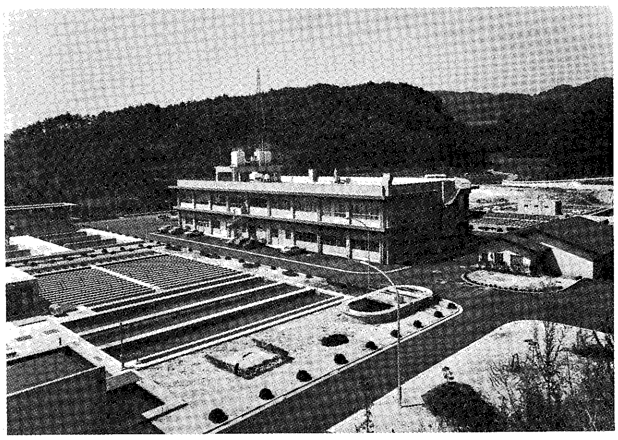


Fig. 1 Exterior view of the waterworks

1) Mission of waterworks

The most important mission is the effective use of vital water resources and stable water supply to meet the increase in water demand.

2) Functions as a control system

The Senogawa filtration plant acts as the control center for the Ohtagawa Eastern region water system.

3) Comprehensive control and filteration plant management

Plant outside control spanning a wide region from water intake to conveyance and management inside the filteration plant be unified.

4) Service water and sedimentation water mixed processing

Service water and sedimentation water have different properties, processing systems, applications, users, etc. and are, of course, managed differently. The two different processes must be skilfully performed concurrently.

5) Long-term facilities plan

Step-by-step expansion of both the water conveyance facilities and waterworks facilities must be forecast and the facilities must be expandable.

6) Intermittent operation and operability

Since the service water system is initially operated intermittently and the machinery must be frequency started and stopped, operation must be easy.

Table 1 Outline of water facilities

Water conveyance facilities			
Trough	1 well	Driving pipe	SP ϕ 2,400 L = 2,631 m
Junction well	Iwanoue 1 well	Driving channel	1.15R modified horse shoe L = 7,792 m
(Sedimentation water) clear water facilities		(Service water) clear water facilities	
Trough	1 well	Trough	1 well
Chemical dosing equipment	1 set	Chemical dosing equipment	1 set
Rapid stirrer basin	2 basins	Rapid stirrer basin	1 basin
Flocculation basin	4 basins	Flocculation basin	1 basin
Sedimentation basin	4 basins	Sedimentation basin	1 basin
Efflux well	1 well	Rapid filter basin	8 basins
Sludge treatment facility	1 set	Chlorine mixing chamber	1 basin
(Sedimentation water) water conveyance facility		Clear water reservoir	2 resevoirs
Regulating channel	2.7R horse shoe L = 753.8 m	Sludge treatment facility	1 set
Trough	Shimotamesumi 1 well	(Service water) water conveyance facility	
Junction well	Sunabashiri 1 well No. 2 Kuninobu 1 well	Service pipeline	SP (ϕ1,200-ϕ1,000) D.C.I.P. (ϕ700)
Service pipeline	Senogawa – Higashikaita SP (ϕ2,400-ϕ1,100) In Kure SP (ϕ1,200, ϕ900)		

Table 2 Outline of system construction

Instrumentation equipment	1)	Computer control facilities	1 set
		Central processing unit (PFU-400 minicomputer)	
		Auxiliary memory	
		CRT display	
		MPCS dataway	
		DDC microcontroller	
	2)	Central control room facilities	1 set
		Operator console	
		Graphic panel (mosaic system, 7 m)	
	3)	Telemetering and telecontrol equipment	1 set
		DISTA-400 (2 : N, N = 13)	
		DISTA-1000 (1 : 1) x 2	
	4)	Industrial television, telephone facilities	1 set
	5)	Instrumentation	1 set
Electric equipment	1)	Constant power supply (for instrumentation and computer facilities)	1 set
		AC 100 V output, 40 kVA	
	2)	Constant power supply (for junction well, dividing facilities)	1 set
		0.5 kVA x 4, 0.75 kVA x 1, 1 kVA x 1	
	3)	DC power supply (for display, DC 24 V)	1 set
	4)	Control center	1 set
	5)	Site panels	1 set

2. Planning policy

Planning was performed on the following fundamental concepts based on these basic conditions:

1) Pursuit of a safe and highly reliable system.
2) Establishment of a general water control system.
3) Improved supervision and operability.
4) Improved controllability.
5) Superior maintainability.
6) Abundant expandability.

These fundamental concepts were incorporated in each facility, but only those that are of special importance will be described.

IV. SYSTEM DESIGN CONCEPTS

1. Pursuit of a highly reliable system

A reliable system can be realized by improving the reliability of each component and balanced organic combination. At the Senogawa plant, a highly reliable system was pursued on the following points.

1) Duplexing of the computer system

Generally, to realize a multi-system, duplexing of the hardware (CPU, Data files, I/O devices) and operation of suited to the plant is necessary.

As shown in *Fig. 2*, the nucleus of the computer system, that is, the important parts of the CPU, main internal memory, and switching controller (SWC), the important parts of auxiliary memory bulk core memory (BCM), and the dataway center port, and the system typewriter are fully duplexed and a hot-standby system shifts all the functions even if a fault should occur in the main online system. The SWC perfectly carry out this state switching.

On the other hand, in addition to duplex operation of the standard software package, bumpless data exchange at system switching and process control protection are performed and the operator can smoothly continue operation control without being aware of the existence of the computer.

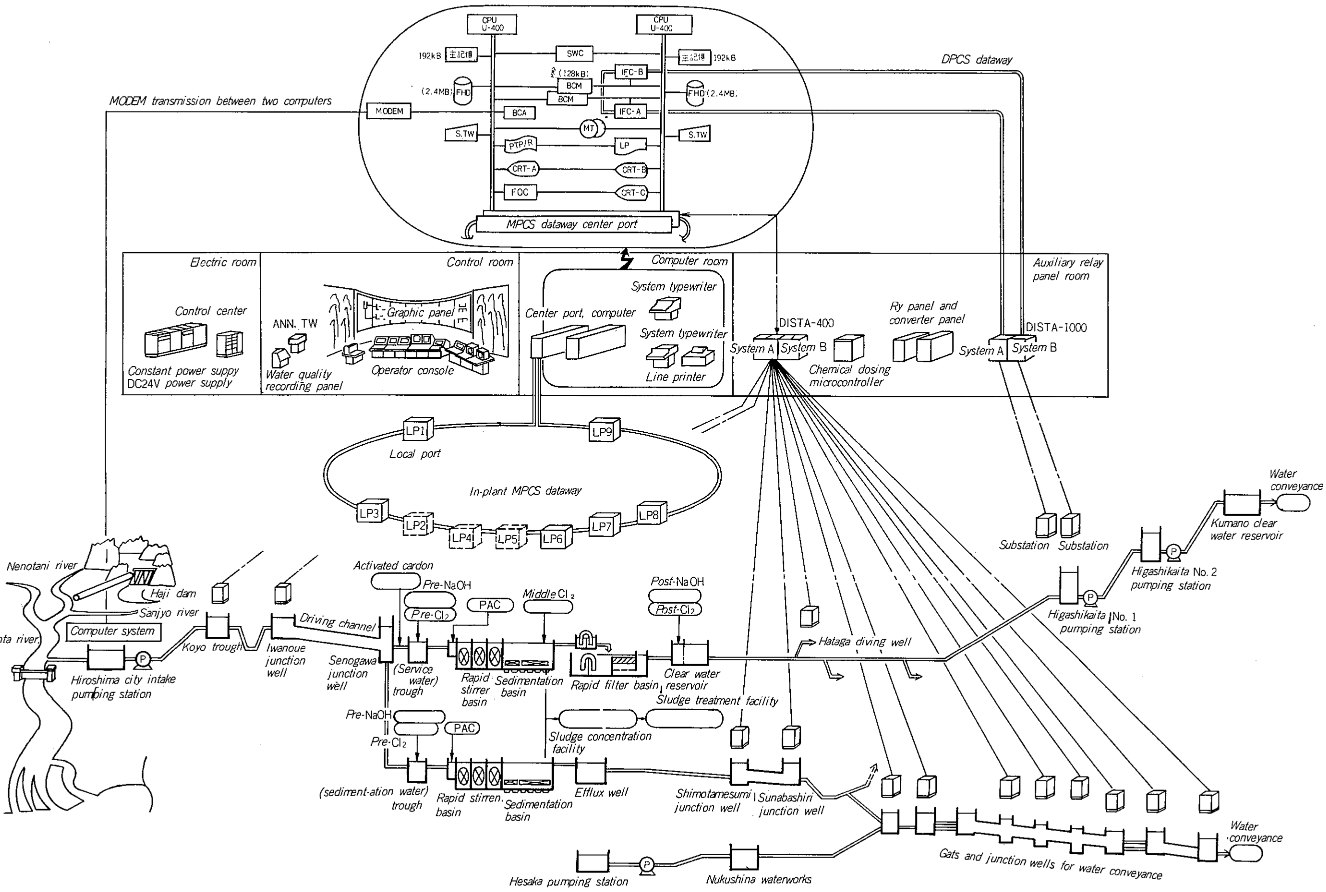
2) Duplexed files

The information that must not be destroyed (alarm history, recording, automatic control system data, etc.) in a duplex system is stored in the BCM. A fast access static type virtually trouble-free BCM was introduced as this file for data reliability and because it is accessed frequently.

3) MPCS dataway

The MPCS dataway system (MPCS) has one data communication circuit (coaxial cable) arranged in a loop and rapidly transmits data between the remote PIO (local ports) distributed around the site by time division.

The MPCS has been made highly reliable by duplexing the hardware of the important parts of the center port corresponding to the interface with the CPU and by detour route formation when a fault occurs in the transmission line and bypass route formation when trouble occurs at a port so trouble at one local port will not affect the total system. Two coaxial cables are also provided. One of these cables



CPU : *Central processing unit*
SWC : *Switching controller*
BCM : *Bulk core memory*
FHD : *Fixed head disk*
BCA : *Basic mode communication adaptor*
S.TW : *System typewriter*
LP : *Line printer*
MT : *Magnetic tape channel*
PTP/R : *Paper tape puncher/reader*
IFC : *Interface controller*
CRT : *Video display*
FOC : *Operator console controller*

Fig. 2 System construction diagram

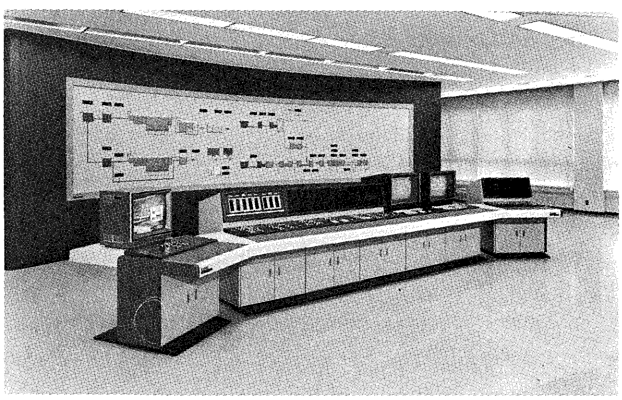


Fig. 3 Control room

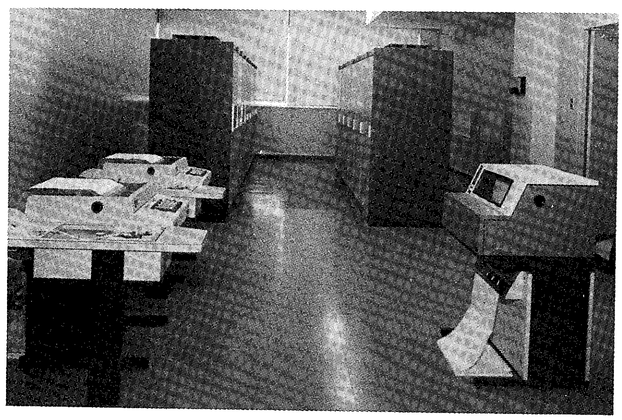


Fig. 4 Computer room

is a spare and complete protection can be expected.

The outline specifications are as follows:

Transmission system : Series 4-wire full duplex channel Intercomfirmation in word units

Modulation system : Frequency shift modulation

Error control : Odd parity and 2 circuit parallel simultaneous collation Automatic retransmission correction system

Transmission speed : 1M bits/sec

4) 2:N telemetering and telecontrol Equipment

The outside facilities are connected by a multi-drop system to form a multiple substation TM/TC system. If one substation is breakdown for short time, it can be conjectured by the preceding and following substation data. However,

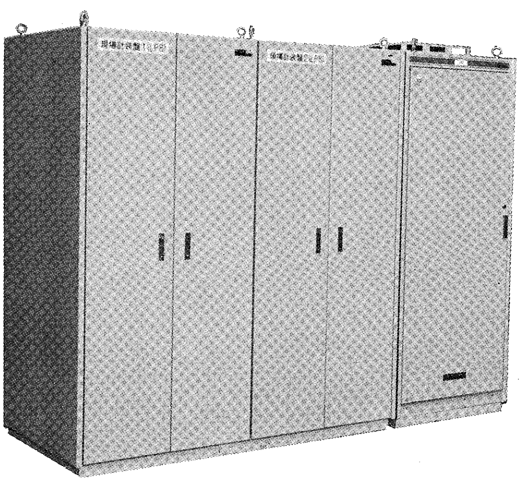


Fig. 5 Local port

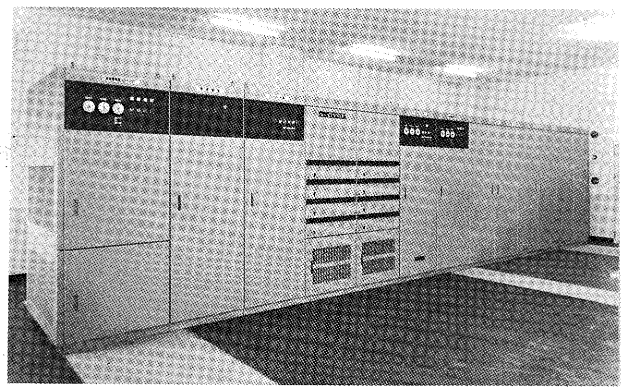


Fig. 7 Constant power supply equipment

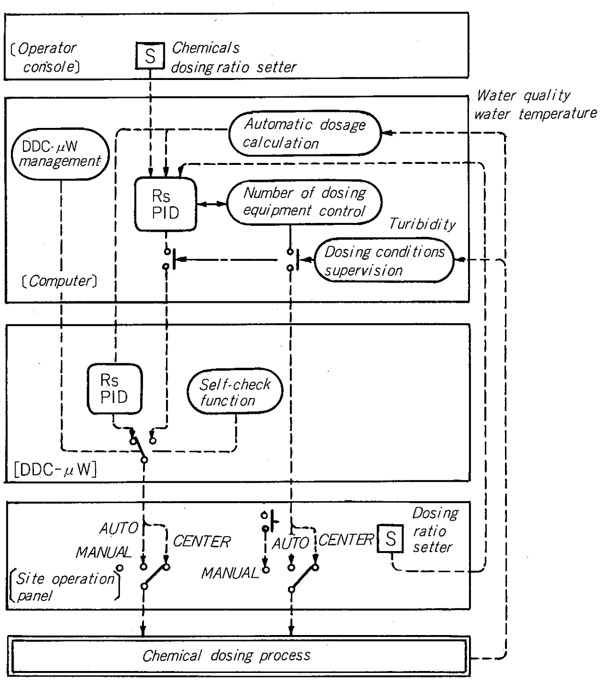


Fig. 6 Chemicals dosing control system

breakdown of the main station stops all outside data processing.

To avoid this, the main station is duplexed and normally operated by a 1:N system and the subsystem master station is on hot-standby. A duplex system which automatically switches to the standby system when trouble in the main system is detected by computer is introduced.

5) Chemical dosing instrumentation

To control chemical dosing, which is vital in service water and sedimentation water processing, a special DDC microcontroller (DDC-μW) was introduced and a computer-DDC-μW-site operation panel hierarchy system was constructed (*Fig. 6*).

Usually, the DDC-μW controls chemical dosing based on computercommands and is backed-up by computor when trouble occurs.

6) Duplexing of supervisory and operation systems

Plant inside and outside supervision and operation are performed from the operator console (abbreviated op/con) through the computer. This system is duplexed (CRT display + process keyboard), (PDP plasma display + ten keyboard) so one can provide support if trouble should occur in the other system. The rationality of operation was checked and safety improved by providing operator error display when the operator makes a mistake.

7) Power supply reliability

A no-break switching CVCF (40kVA) was installed in the plant as the instrumentation and computer power supply.

Since a facilities power failure also has an affect on the entire system, a small constant power supply was installed outside the plant. Since the capacities are a small 0.5, 0.75, and 1.0kVA, a transistorized system featuring high efficiency and space saving was introduced.
This increased the power failure compensation time for the same storage battery capacity.

2. Water operation control

Water operation control is performed by deciding the water-intake plan by automatic calculation by computer and posting the required water-intake for the Hiroshima Koyo water intake plant. This is illustrated in *Fig. 8*.

1) Water intake and conveyance control

The filteration plant and water intake plant computer systems are MODEM connected and the intake water demand is transmitted as 20 minutes interval 12 hour time series data four times a day. The water intake plant confirms this and controls the water intake pumps.

The Driving channel was planned for 550,000m^3/d. It is a complex control system that interchanges the filled

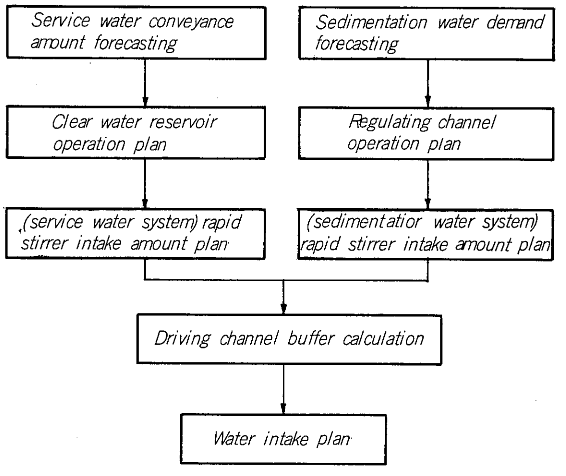


Fig. 8 Flow diagram of water operating calculation model

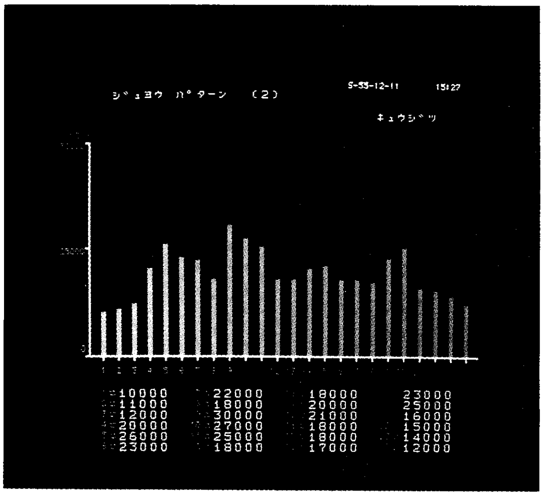


Fig. 9 Demand pattern display

water and conduit water according to the initial flow amount. Therefore, water processing simulation was performed with a large computer and safe water intake and conveyance operation decision judgement data was obtained.

2) Service water conveyance amount control

The total diversion flow is decided on the service water on demand plan, an operating plan is established to smoothen the filtered water flow by using a clear water reservoir buffer and the rapid stirrer basin inflow amount is controlled. Since intermittent operation is performed in the beginning, forecast control is not performed.

3) Sedimentation water conveyance amount control

At the No. 2 Kuninobu junction well, this system converges with the Otagawa eastern region industrial waterproject phase 1 system and is conveyed as source water for service water or industrial water.

At the Hesaka water conveyance system, the demand pattern is selected by CRT and the No. 2 Kuninobu convergence flow is decided by adding the phase 1 system flow when the water convergence open channel flow is delay. Three CRT patterns are provided, weekday, holiday, and arbitrary setting because the major portion is industrial water. An example is shown in *Fig. 9*.

The system was designed by confirming safe operation and control by simulating the regulating channel and water conveyance system.

3. Completion of man-machine interface

A centralized supervisory and control system that can be operated by a small number of personnel is used for water conveyance- clear water-water conveyance operation control. This system offers excellent supervisability and operability and further completes the man-machine interface functions for safe operation and so the ample experience and sophisticated judgement of the operator can be utilized. In the control room, the graphic panel, CRT, and op/con functions load was optimized and normal operation

Table 3 List of CRT displays

Type of display	Quantity	Display contents
Process skeleton	18	Display of the data and equipment of each process by changing the color and form.
Overall process skeleton	2	Display of the sedimentation water system, service water system process water quality and chemical dosing state.
Plane display	1	Flicker display of symbol of abnormal equipment on waterworks plane display when an alarm is generated.
Data display	3	Process data table display.
Operation plan display	8	Display of operation pattern and plan value used by operating plan.
Graph display	2 kinds	Hourly bar graph and irregular interval (shorter interval as the data becomes newer) point graph display.
Report display	44	Daily report and monthly report data display.
Control status display	6	Sedimentation basin, filter basin, chemical dosing control status display.
Alarm item list	1 kind	Current alarms table.
Others	3	Test pattern, etc.

and abnormality processing were clarified.

1) CRT display

The two CRT, which form the center of information service, back-up each other by means of special operation keys. (Three CRT when the Higashikaiṭa system is included.)

The screens displayed most frequently are displayed by one touch with a special function key and the forms and graphic displays are displayed by means of character and numeric keys.

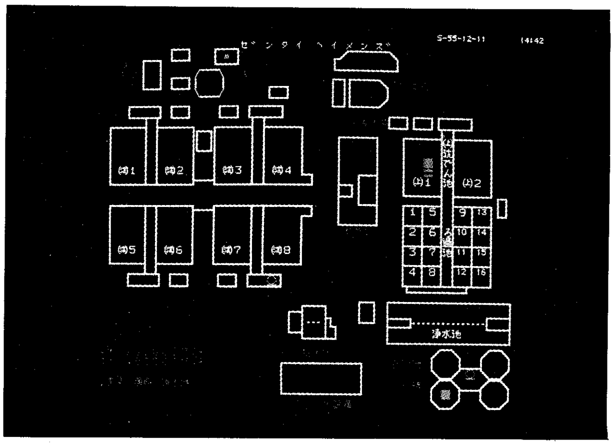


Fig. 10 Whole plane display in waterworks

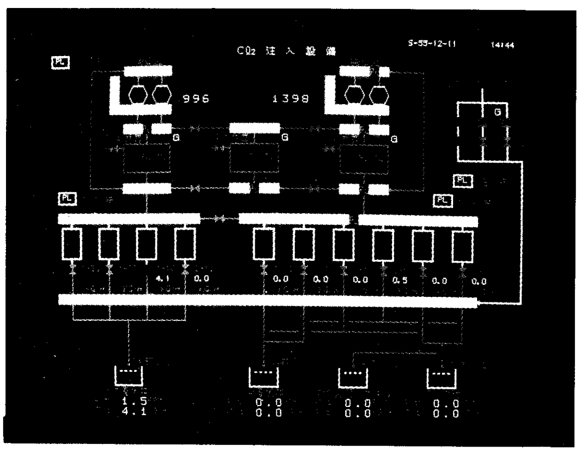


Fig. 11 Skeleton display

Fig. 12 Announcement message display

Since this CRT can display 4000 characters and can also display Chinese characters, it provides an easy-to-read display.

Table. 3 outlines the kinds of displays and *Figs. 10* to 12 show some typical displays. The whole plane display in waterworks of *Fig. 10* permits macro supervision by blinking the pertinent equipment installation site in yellow when an alarm is generated and the skeleton display (*Fig. 11*) which blinks the abnormal equipment and data in yellow and the announcement message display (*Fig. 12*) which displays the abnormal contents and operation guide that guides the next operation permit micro supervision.

2) Graphic panel

The graphic panel provides and overall grasp of the process based on harmonization of the other man-machine equipment. In this system, as water level and water flow operation and control become the focus and it were reduced for simplicity. The water level and water amount data are distributed to the three digital displays along the plant flow.

3) Operater console (op/con)

To correspond to graphic panel, the op/con was made a central type and all supervison and operation are performed from the seat. Therefore, the op/con was designed to permit operation by feather touch.

(1) Block alarm

The plant is divided into a number of blocks and priority confirmation is performed first whenever alarm is generated. These blocks and the CRT skeleton display have 1 : 1 correspondence.

(2) Important equipment individual display

Display of especially important alarms is set individually and promotes quick processing.

(3) System abnormalities

System components alarms are displayed and posted individually.

(4) PDP plasma display

The PDP has the following functions:

(1) Data display and equipment status and alarm display
(2) Equipment operation from ten key
(3) Program start command

4) Alarm typewriter

The alarm typewriter types out the message contents when alarm occurs as an operator daily log.

5) Line printer

The daily and monthly reports are prepared at the line printer. The CRT display can also be copied at the line printer.

4. Computer process control

Besides the water operation control previously described, the following computer process control is performed:

1) Service water system intermittent operation

An automatic intermittent operation program was

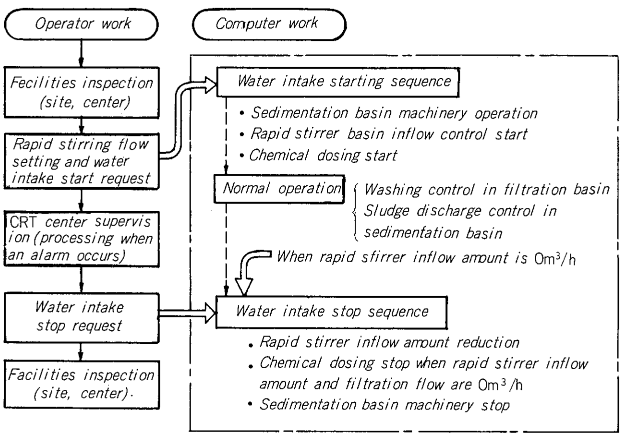


Fig. 13 Function allotment of auto intermittent operation

developed because intermittent operation is necessary when the service water demand is low, at first.

Fig. 13 shows the allocation of the operator and computer functions.

2) Chemical dosing control

As shown in *Fig. 6*, the chemical dosing ratio is automatically calculated by computer from the water quality and water temperature data, or is set from the operator console or site panel analog setter.

Table 4 is a calculation model of the dosing ratio.

3) Filter basin control

The computer monitors the washing conditions and controls washing from the filter basin that reaches the conditions first. These conditions are:

(1) Arrival of specified continuous filtering time

The filtering time is accumulated and washing sequence control is started when the time set at the operator console is reached.

(2) Filter head loss upper limit

When the filter head loss upper limit is detected by the electrode, washing sequence control starts.

(3) Operator request

Control is started by washing request from the operator console.

The progress of the washing sequence is displayed on the CRT and the interval can be set from the operator console.

4) Sedimentation basin sludge discharge control

The computer monitors the sludge discharge conditions at a fixed period and removes the sludge from the hopper when the set conditions are reached. The conditions are as follows:

(1) Accumulated sludge upper limit

The upper limit is automatically calculated from the raw water quality, chemical dosing amount, etc. The procedure for a sedimentation water in sedimentation system is described below. The procedure is the same for the service water system, except that the activated carbon dosing amount is added to the Ds value.

1) Total solids generation

$D \quad Ds = Q\,[(Tb - Tb')a + P\gamma] \times 10^{-3}$ (kg)

Q : Rapid stirrer inflow

a : Turbidity conversion coefficient (SS conversion)

Tb : Raw water turbidity

Tb' : Sedimentation water outlet turbidity

P : PAC dosing ratio

γ :: PAC sedimentation coefficient

2) Removed sludge (Vs)

Since it is dry solid and there is not actual removal, it is converted from the equation below.

$Vs = Ds/R_1$

(R_1 : Removal density)

3) Sludge amount to each hopper

Since the sludge is distributed along the water flow, for three hoppers,

$V_{si} = 1/2 V_s \cdot r_i$

[r_i : Sludge distribution ratio ($i = 1 \sim 3$, $\overset{i}{\Sigma}\, r_i = 1$)]

4) Accumulated sludge upper limit

$V_{si} \geqq V_{s\max}$ Sludge discharge when (hooper full).

(2) Arrival of sludge discharge period

1) Number of removals of each hopper (C_i)

$C_i = V_{si}/(V \times R_2/R_1) = V_{si}R_1/VR_2$

[V = Hopper capacity, R_2 : Hopper sludge density]

2) Removal period per hopper (T_i)

$T_i = 1/C_i$

(3) Arrival of sludge discharge period

The sludge is discharged when the sludge discharge interval counter (T_{ci}) reaches $T_{ci} \geqq T_i$.

3) Sludge boundary upper limit

When the upper limit is detected by the sludge boundary meter installed at each of three hoppers, the sludge is discharged at the same group and same stage.

4) Operator request

The operator can judge the status at the CRT sludge discharge status list display and request sludge discharge.

5) Power factor adjustment control

To maintain a high power factor at the power receiving points, a power factor improvement capacitor (SC) is installed in the 6 kV bus. The controlled SC capacity is 50, 75, 100 kVA (150, 200 kVA in the future). Combination of 25 kVA step reactive power control and power factor control is also possible.

Frequent operation is avoided and the number of switchings of each SC is made uniform by providing a dead time after ON/OFF operation.

Since the SC are selected by decision table, the addition of SC can be easily met by simply changing the table.

6) Contracted demand supervision

The received power is monitored and when the contracted demand is exceeded, ykW over is output by alarm message after x minutes.

5. Special equipment

1) Control center

All the equipment, except for the chemical dosing system that must be supervised and controlled at the site

Table 4 Calculation model of dosing ratio

(Service) PAC dosing ratio

1) $P_1 = ai \cdot \sqrt{Tn} + bi$	Tn	: Raw water turbidity
$P_2 = c \cdot Qn + d$	Qn	: Raw water temperature
2) ① When $\theta < 13°C$ at $T < 20$ ppm, (P_1, P_2) whichever is larger is used	ai	: Constant that varies with the raw water turbidity
② P_1 is used except at the above.	bi	: Constant that varies with the raw water turbidity
	c	: Constant
	d	: Constant

(Service) Pre- NaOH dosing ratio

$N = [(ALs + kPn) - ALn] \cdot f + j \cdot Cn$	Pn	: PAC dosing ratio
	ALn	: Raw water alkalinity
	Cn	: Pre- Cl_2 dosing ratio
	ALs	: Sedimentation water residual alkalinity target value
	k	: Coagulant constant (0.18)
	f	: Alkali material constant (3.25)
	j	: Chlorine caustic soda consumption

(Service) Post- NaOH dosing ratio

1) $N_1 = N(n\text{-}i) + k \cdot (PH's - PH'n)$	$N(n\text{-}i)$	: Dosing ratio before i samplings
	PHn	: Clear water reservoir pH
2) $N_2 = (PH's - PH'n) \times a$	PHs	: Clear water reservoir pH target value
① N_2 is used at initial dosing ($i \times \Delta t$ minutes)	k	: Constant
② N_1 is used after $i \times \Delta t$ minutes.	$PH'n$	: Sedimentation water pH
	$PH's$	: Sedimentation water pH target value
	a	: Constant

(Service) Pre- Cl_2 dosing ratio

1) $C_1 = C(n\text{-}i) + k \cdot (Ros - Ron) + l$	$C(n\text{-}i)$	: Dosing ratio before i samplings
2) $C_2 = (a_1 NH_4^+ + b_1) + [a_2 (Kn)^e + b_2]$	Ron	: Sedimentation water residual chlorine.
① C_2 is used at initial dosing ($i \times \Delta t$ minutes).	Ros	: Sedimentation water residual chlorine target value.
② C_1 is used after $i \times \Delta t$ minutes.	k	: Constant
	l	: Constant (compensation term)
	NH_4	: Ammonium nitrogen
	Kn	: Activated carbon dosing ratio
	e	: Exponent
	a_1	: Constant (NH_4^+ chlorine comsumption)
	b_1	: Constant (consumption at sedimentation basin)
	a_2	: Constant
	b_2	: Constant

(Service) Middle Cl_2 dosing ratio

1) $C_1 = C(n\text{-}i) + k \cdot (Ros - Ron)$	$C(n\text{-}i)$	: Dosing ratio before i samplings
2) $C_2 = a \cdot (R'os - R'on) + b$	Ron	: Filtered water residual chlorine
① C_2 is used at initial dosing ($i \times \Delta t$ minutes).	Ros	: Filtered water residual chlorine target value
② C_1 is used after $i \times \Delta t$ minutes.	$R'on$	: Sedimentation water residual chlorine
	$R'os$	: Sedimentation water residual chlorine target value
	k	: Constant
	a, b	: Constant

(Service) Post- Cl_2 dosing ratio

1) $C_1 = C(n\text{-}i) + k(Ros - Ron)$		
2) $C_2 = a\ (R'os - R'on) + b\ C(n\text{-}i)$		: Dosing ratio before i samplings
① C_2 is used at initial dosing ($i \times \Delta t$ minutes).	Ron	: Clear water residual chlorine
② C_1 is used after $i \times \Delta t$ minutes.		: Clear water residual target value
	Ros	
	$R'os$	: Filtered water residual chlorine
	k	: Constant
	a, b	: Constant

(Sedimentation) PAC dosing ratio

1) $P_1 = ai \sqrt{Tn} + b$	Tn	: Raw water turbidity
2) $P_2 = C \cdot \theta n + a$	Qn	: Raw water temperature
① No dosing when $Tn < 13$ ppm	ai	: Constant that varies with the raw water turbidity
	bi	: Constant that varies with the raw water turbidity
② When $\theta < 13°$ at $13 \leqq Tn < 20$ ppm	c	: Constant
③ The larger of (P_1, P_2) is used.	a	: Constant
P_1 is used at other than the above.		

(Sedimentation) NaOH dosing ratio

$N = [(ALs + kPn) - ALn) \times f$	Pn	: PAC dosing ratio
	ALn	: Raw water alkalinity
	ALs	: Sedimentation water residual alkalinity target value
	R	: Coagulant constant (0.18)
	f	: Alkali material constant (3.25)

(Sedimentation) Pre-Cl_2 dosing ratio

1) $C_1 = C(n\text{-}i) + k\ (Ros - Ron) + l$	$C(n\text{-}i)$	: Dosing ratio before i samplings
2) $C_2 = a \cdot NH_4^+ + b$	Ron	: Sedimentation water residual chlorine
① C_2 is used at initial dosing ($i \times \Delta t$ minutes).	Ros	: Sedimentation water residual chlorine target value.
② C_1 is used after $i \times \Delta t$ minutes.	k	Constant
	l	: Constant (compensation term)
	NH_4	: Ammonia nitrogen
	a	: Constant
	b	: Constant

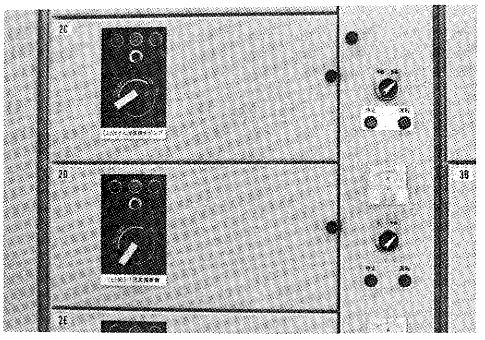


Fig. 14 Expansion of control center unit

Table 5 Water quality sampling points and items

Sampling point	Sample name	Quality	Measurement range
Senogawa junction well	Raw water	Turbidity (high)	0~2,000 ppm
		Turbidity (medium)	0~ 200 ppm
		Turbidity (low)	0~ 20 ppm
		pH	2~ 12
		Conductivity	0~200μ℧/cm
		Alkalinity	0~ 50 ppm
Service water system sedimentation basin	(Service) sedimentation water	Turbidity	0~ 20 ppm
		Residual chlorine	0~ 3 ppm
		pH	2~ 12
		Alkalinity	0~ 50 ppm
Service water system rapid filter basin	(Service) Filtered water	Turbidity	0~ 5 ppm
		Residual chlorine	0~ 3 ppm
		pH	2~ 12
Service water system clear water reservoir	(Service) Clear water	Turbidity	0~ 5 ppm
		pH	2~ 12
		Residual chlorine	0~ 3 ppm
Sediment water system sedimentation basin	(Sedimentation sedimentation water	Turbidity	0~ 20 ppm
		pH	2~ 12
Sedimentation water system efflux well	(Sedimentation) sedimentation water	Residual chlorine	0~ 3 ppm

panel, can be operated from the control centers scattered around the plant. Since they are grouped by system, the system can be controlled while observing the status of the associated equipment. This reduces the number of site panels required significantly. An example is shown in *Fig. 14*.

2) Water quality analyzer

Online measurement measures the turbidity, pH, conductivity, alkalinity, and residual chlorine, *Table 5* shows the sampling points and measurement ranges. The raw water turbidity, pH, and conductivity are sampled by natural fall from the junction well so they can be measured even during a power failure. Other samples are sent to the water quality analyzer room on the second floor of the main building.

The water quality analyzer itself is a mounted type and inspection passage is provided and ample consideration has been given to maintainability.

3) Flowmeter

Since flowmeters are the foundation of water operation and control, they must be reliable and accurate. Magnetic flowmeters were used at small diameters and ultrasonic flowmeters were used at large diameters for economy.

V. CONCLUSION

The comprehensive water control system in the Senogawa filtration plant was outlined above. Continued expansion of this system is planned, but since the fundamental design concepts have been established, it will be able to quickly cope with expansion.

In the future, further operating records will be accumulated and data collection and analysis will be performed and the water operation control, chemical dosing control, and other software will be further refined and other efforts will be made to achieve an ideal system. This system is a type of prefecture waterworks expanded to a wide region and indicates the future trend of waterworks management for the regional age.

Finally, the authors wish to thank the relevant persons at the Hiroshima Prefecture Industrial Policy Bureau for their counsel and guidance and request more guidance from now on.