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TECHNICAL TREND OF INSTRUMENTATION & CONTROL AND ELECTRIC MACHINERY FOR WATER AND SEWAGE WORKS IN JAPAN

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I. FOREWORD

In Japan, the water supply and sewage facilities have been greatly expanded. Although the recent suppression of the public investment has caused the expansion to be slow, the expansion will be constantly continued as of its importance for the health and welfare administrations.

The water supply and sewage facilities built recently feature the high technology, automations and rationalizations, and electric machinery and instrumentation·control technologies are greatly contributing as well as the civil engineering and mechanical engineering technologies. Especially, the extreme increase of the roles of electric machinery and instrumentation taken in the water supply and sewage has changed the state of the water and sewage works.

Even the water and sewage works are likely to be developed by harmonizing the changes of the social thoughts, changes of the needs caused by the changed social thoughts and advancements of the electric machinery and instrumentation. It may be said that this harmonizing has been made extremely well during these several years.

Today, however, new changes are seen in the water supply and sewage administrations, and keeping the pace with the rapid change of the electronic technologies represented by micro-computers, this field seems to be in a turning point. It will be meaningful to overview the water supply and sewage system technologies at this opportunity.

Special issues have been made for the system technologies for water since 1974 in this FUJI REVIEW for eight years, and during these years, Fuji Electric has accomplished number of performances with its long experience and accumulated system technologies. Further, coping with the time-to-time demands and customer's requests, Fuji Electric has observed the technical trends clearly, and polished up the engineerings and technologies continuously. This paper overviews the technical trend of the water and sewage works and present status of the electric machinery and instrumentation for the water and sewage works.

II. TREND OF WATER SUPPLY AND SEWAGE WORKS

During the period of high growth of society in Japan, the movement of the water supply and sewage works was coincided with the health and welfare administrations timely and properly, and constructions of the facilities were developed greatly.

As the time moves into the low growth period, however, the quantity has been turned over to the quality, and the constructing era has also been turned over to the maintenance era.

In 1980, the water supply was accomplished to 91.5%, and in major cities, it reached almost 100%. As for the sewage works, the 5th 5-year project is being proceeded, and the popularization reached up to 33% in 1981. In the future, it will be diffused from the major cities into local cities, and the constructions are proceeded by aiming at 44% in 1985. Under this circumstance, this paper overviews trends of the water and sewage works. (Refer to *Table 1.*)

(1) Groping new water supply systems

As a new index in place of quantity, the new indexes centered around the quality such as stabilization of water supply, safety of water quality and healthy water supply management are groped. The new era has begun to look for multiple indexes rather than single index and more tasty and higher quality water is looked for.

(2) Era of maintenance and management

The constructing era centered around the quantity is now turned over to the era of maintenance and management in which the built up facilities are operated more efficiently. For this purpose, aiming at the improvements of safety and efficiency of the facilities, already installed systems are remaintained and revised. Enhancing the level, rationalizing and employing automations, those facilities which can be easily maintained and controlled, those of safe operations or of maintenance free are looked for.

(3) Arrangements of water supply and sewage systems in the local cities

Table 1 Technical trends of water and sewage works

Trend	Facility	Practical countermeasure
Stable management and operation	Stable intake and water supply	Wide area water supply and dam operating technologies
	Safe water supply	More precise water quality supervision
	Blocking and adjustment of water distribution	Water operation management and water distribution control
	Advanced sewage processing	Tartial processing control and oxygen airation control
	Water supply data management	Water supply data network
	Countremeasure for disasters	Water supply management at earthquake, prevention of disaster in water supply, countermeasures for heavy rain and flood, hypochlorinating control, and balanced water supply at water shortage
	Updating facilities	No down replace
Energy saving	Preventing water leaking	Water distribution control and water leakage detecting method
	Chemical saving	Optimization of chemical control
	Collecting energy	Small size hydraulic power generation, collection of waste heat, power generation by sludge digestion, and methane fermentation control
	Power saving	Pump and blower variable speed controls
	New energy	Utilizations of sun heat and solar power generation
Prevention of public nuisance	Total restriction of water quality	Organic pollution meter and exhaust gas measurement
	Total restriction of exhaust gas	Burning furnace control and exhaust gas measurement
	Countermeasures for minor polluting substances	Minor volume water quality meter and detection of poisonous substance
	Sludge treatment	Burning furnace control and central sludge control
	Countermeasures for odor	Active carbon and ozone deodoration
Era of local cities	Countermeasures for permanently living zones	Sewage system at small urban villages
	Optimizing technologies	Small size monitoring system (MICREX-M), rotary disc method, and oxydizing pond method controls
New era of water supply	New water supply system	
	Tasty water	Taste measurement, high level processing, and measurement of minor substance
	Stable supply	Torerance of facility against disaster and updating pipe lines
	Water supply to all nationals	Rearrangement of local water supply and wider area water supply
	Management improvement	Ratinalization of maintenance control and maintenance free
	Service for citizens	Measurement of level of satisfaction
	Water management of rivers	Comprehensive water supply and sewage system along rivers
International cooperations for water supply system	The 10-year project for drinking water supply and sanitations of the United Nations (1981 through 1990)	

As the idea of establishing permanently living zone and era of local cities are suggested, constructions of the water supply and sewage works are now dispersed from the major cities to the local cities. For the facilities in local cities, the features which are peculiar to that local areas and differ from those of the major cities are emphasized, and they tend to be varied as the individuality, feasibility, economy and maintenance ease are improved. Thus, new and various processing technologies are being introduced.

(4) Enhanced maintenance of water quality

As the cities are developed and grown, water supply source is polluted, and appearances of harmful substances such as trihalo-methane have caused requirements of higher water quality control. On the other hand, the total restrictions of water quality have requested severer restrictions at the sewage treatment works. Especially, in the bay and lake areas, restrictions of COD, phospher and nitrogen are being enhanced. For these purposes, new water quality measuring methods and rearrangements of wider area water quality control systems are required.

Water circulating systems, water and sewage systems which completely meets with the natural water circulating system, and management of water which takes the overall stream areas into the considerations are required.

(5) Effective use of water resources

Developments of new water resources have become difficult, and the limited water resources have been recognized. For the water supply systems, to use the limited water more effectively, area of water supply system has been expanded, and single-dimensional water management has been promoted so that water can be supplied evenly to the wider areas by effectively using the water supply facilities. At the same time when securing water resources, countermeasures are taken to prevent water leakings from the water supply pipe lines so that such a target as to achieve 90% effectiveness can be accomplished.

In the sewage systems, recirculation and reuse of sewage are promoted, and in many cases, the water is used for industrial and miscellaneous purposes.

(6) Energy saving

For both the water supply and sewage systems, larger the scale of the facilities, the more energy are seriously examined. For both the water supply and sewage systems, pump and blower speed controls are actively introduced to save power as the typical countermeasure.

Small size hydraulic power generations at water supply system, industrial and agricultural water supply systems are now practically operated.

In the sewage systems, methane gas power generations have been tested by using sludge digestion to be practical, and actual plants have been operated at several places. Using the wide area of water and sewage facilities, solar power generating plans has also been examined.

(7) Countermeasures for disasters

Water supply systems which withstand against artificial and natural disasisters such as earth-quake, typhoon and shortage of water have been recommended, and more safe and stable facilities and operations are required.

Great accounts are placed on the reliabilities, backing-up countermeasures and quick recoveries.

(8) Updating the electric machinery and instrumentations

It is generally said that electric machineries are updated once every 15 to 20 years, and once every 10 years for the instrumentations. Also in the water supply and sewage facilities, machineries and instrumentations begin to be updated. In the water supply and sewage facilities which mainly consist of civil engineering facilities, such a concept as to update large size equipment has initially appeared, and for updating the electric machineries and instrumentations of which the technological advancements are rapid, new technical methods must be created.

(9) Automation of peripheral equipment

Next to the automations of filteration plant and treatment plant, automations of the peripheral facilities such as pumping stations and sludge treatment facilities are practically proceeded, and at the same time, such trend has been developed to hierarchical managements of all the facilities outside the premise. Further, new problems other than water such as air pollution due to exhaust has generated by burning sludge, sludge treating odor and combustion control of burning furnace have occurred.

(10) International cooperations

The 10-year project for drinking water supply of the United Nations has started, water supply works assisting programs for the undeveloped countries have been made practically, and the promotions have become very active. As one of the leading countries, Japan has been asked to actively participate in the technical training and assistance programs.

III. TREND OF INSTRUMENTATION · CONTROL TECHNOLOGIES AND ELECTRIC MACHINERY

Amongst various water and sewage technologies, changes of the electric machinery and instrumention technologies are most remarkable. The micro-electronics and power electronics technologies have made the system engineerings centered around the electric machinery and instrumention technologies entirely new. Variety of models, performance improvement, reliability improvement and cost performance improvement are realized on the computers, data transmission systems, measuring devices and instruments, control equipment and electric machineries, providing new seeds. With these new technologies, any equipment and systems can be selected freely and flexibly, system composition can be made easily, and variety of the system can be realized from a large scale system to small scale system. For this reason, the optimum system which perfectly meets with each facility, scale and local characteristics can be realized.

3.1 Computers

As the centralized management and decentralized control systems which are centered around a computer system are settled down, the hierarchical configuration has varied. In the highest level, the new type 32 bit super-minicomputer (PFA-3000 series) is located, greatly expanding the management functions. As a high level computer, there are various models of control computer (PFU-1000 series), and these computers manage and control the systems.

In the lower levels, micro-computers for multi-loop controls (MICREX-W system) are available, allowing systems of 4, 8, 16 and 32 loop in the unit of four loops to be composed. Being affected by the recent personal computer boom, the micro-computer which combines the main unit, CRT display, floppy disc, keyboard and printer into a single unit has been likely to built in the system.

The micro-computer for control has realized the single loop controller (CC-F) as an equipment which aims at the extremely high reliability promised by the decentralization, and thus, sufficiently satisfied the lowest layer of the hierarchical composition.

The individual computers which compose these hierarchies are connected both vertically and horizontally by the data transmission network, from a large scale system to a small scale system, system compositions can be made in various ways, from a system to stand alone type.

As the super-minicomputer has appeared, large systems of water supply management system, water supply data service system, water operating system, wide range water supply system, etc. can be composed easily.

The conventional filteration plant management, treatment plant management, water distribution control and water quality monitoring system can be composed in a single system as a medium size system, or in a hierarchical system by combining with a higher level system.

A multi-loop micro-computer system composes a control of each unit process of water filteration process and sewage treatment process as a local station of decentralized contorl. Single loop micro-computer and personal computer have allowed employments of computers in the small scale water supply systems in medium or small city because of its economy.

To compose a system with two or more computers, a network (MAXS system) is used. This network couples the computers and peripheral equipment in a matrix. With this system, load sharing and decentralization of function are eased amongst the computers, and the peripheral equipment can be used commonly. This system is used to compose duplex and triple computer systems, and this system is used widely for multi-processor systems, load sharing to improve reliability and back-up systems.

3.2 Data transmission equipment

In a system which uses many types of computers, hierarchical compositions of computer system or decentralized control system which uses many computers as the components, data transmissions amongst the computers are extremely important. For the data transmitting equipment, transmission capacity, high responsibility, reliability and

economy are required, and the advancements are extremely remarkable. Recently, with the advanced optics applied technologies, data transmissions by the use of optical fiber have been realized. Further, the transmission equipment are improved to be intelligent types by using micro-computers, and many of them are transmitting data while processing the data simultaneously.

Also for data transmissions by radiowaves, not only the conventional 400 MHz band but also 2 GHz band are used, and MCA system of 800 MHz band has also started.

For data transmissions amongst computers, there are two systems depending on the scale of the system. One of them is a large size data way (MPCS) located in the higher level of the mini-computer hierarchy, and the other is a small size data way (DPCS) used for data transmissions amongst lower level micro-computers.

With these two systems, both vertical and horizontal data transmission systems can be composed freely.

As a telemeter telecontrol equipment, new type intelligent telemeter (SAS series) has been developed by using micro-computer. In addition, preparing for expanded use of subscriber telephone lines of The NTTPC, Non Ringing system subscriber telephone channel transmitter is available.

In these days, sequence control is applied in the most cases, and as a device which performs contact transmission of sequence in wire sharing, there is an intra-premise transmitter, and this equipment is assisting cable wiring saving.

With the advancements of transmitting equipment, water and sewage work management range has been greatly expanded, and at the same time, new management systems have been produced.

With the data way system, decentralized control systems for filteration plants and treatment plants have been settled down, and wiring work has also been greatly simplified.

With the telemeters which use intelligent systems, outside premise monitoring control has been enhanced, and wide range water supply system, water operating system, water distribution control, unattendence for pumping stations, sewage trunk line monitoring control, unattendence for pumping substation, etc. have been promoted.

The subscriber telephone channel using technique is effective in economical intermittent monitoring, and this technique is planned to be applied to the water pollution supervising system, automatic metering of water supply and group management of small size treatment plants in towns and villeges. The radio telemeter telecontrol monitoring is used for a large scale wide range water supply system, and examinations are made also to use it as an auxiliary system to manage water distributions in case of an earthquake, flood and other disasters.

3.3 Sensors

While the data processing and transmission technologies are being advanced rapidly, efforts are concentrated to develop the sensors which function as the data or information sources.

Solid state general purpose measuring instruments are used more and more, and those of 0.2% class accuracy have been popular.

For the flow meters, electromagnetic flow meters and ultrasonic flow meters are futher improved, and the application range has been expanded. Recently, micro-computer built-in flow meters have appeared also.

Ultrasonic flow meters of small bore low flow ranges are added to the conventional ones, and series of meters cover from small bore to large bore. Applications of open channel flow measurements and non-filled pipe flow measurements are being tried at various fields, and discharged water volume can now be measured at sewage outlet pit and flow of trunk non-filled pipe line can also be measured. Also portable ultrasonic flow meters are capable of measuring flows toward all bores, and applied usefully to various purposes such as terminal water distribution status check, water leaking check, water management by each application within a premise and flow meter back-up.

As for detections of leaked water, various efforts are being made continuously. A relative measurement method using sound propagation has been reported, and now, it is used practically. For water quality sensors, on-line models for measurements of turbidity, pH, residual chlorine and alkalinity in the water supply systems have been almost stable. Recently, measurements of very minor, substance which is seen in trihalomethane have been taken up as problems.

In the sewage systems, on-line instruments for DO meters and MLSS meters have been almost stable. Because of the total quantity restrictions, organic turbidity meter (UV meter) has been developed and used for wide applications.

As for measurement for water quality in sewage systems, the maintenance is the largest problem. To solve this problem, such a method as to measure gas component of exhaust gas from sanitary sewage and to measure water quality through relative calculations by the use of a micro-computer has invited interests of the people concerned. Since the data processing ability of a micro-computer can be applied to measuring instruments, this method is being expected as a maintenance-free measuring method. The respiration ratio meter which measures exhaust O_2 gas in airation basins and COD-O_3 meter which uses ozone gas for the oxidizing solution are instruments of this type, and these instruments are accepted very favourably.

In cope with such new problems as total restrictions of phosphor and nitrogen, developments of automatic phosphor and nitrogen analyzers have been promoted.

Simultaneously with the development of water quality meters in the water supply and sewage systems, automations of water quality inspection room will be the important theme for the future. Since laboratory automations are promoted at the individual industries, automations of water quality inspection rooms will be realized comparatively easily.

In the recent water supply and sewage measuring instruments, the gas analyzers must be reported as topics. Conventionally, gas analyzers were not required in the water and sewage systems. However, as level of sludge treatment control is enhanced, and prevention of air pollution, reuse of methane gas and ozone deodor technologies are improved, various gas analyzers for methane gas, O_2, CO, CO_2, NOx, SO_2, ozone, etc. have been required.

These gas analyzers are being used for managements of sludge digestion basin, combustion control of sludge burning furnace, air pollution exhaust gas monitoring, ozone deodor, exhaust gas monitoring of sterilization, managements of worker safety in ducts and manholes, etc.

3.4 Man-machine interface

As the micro-electronic technologies are advanced, various man-machine interfaces have been made.

On the other hand, maintenance managements are enhanced and operating reliabilities have been requested. Because of these situations, various man-machine interfaces have been used.

For both the hardwares and softwares, CRT displays have been remarkably advanced as a star player of the man-machine interface, and improvements of the functions are extremely remarkable. Conversation type image drawing, image movement, image enlargement and reduction and other display methods suited to water supply systems have been developed. With virtual keyboards, light pens, joy stick, mause, etc., more accurate and faster operating control and monitoring can now be made.

For recording systems, Chinese character printer has appeared, and readily read data records have been provided economically.

As the LSI for audio systems is used practically, audio synthesizing and audio recognition have been realized easily. With these audio I/O devices, audio alarm display and audio orders have been used.

3.5 Software

The importance of software has rapidly been risen as size of computer system is increased, and types and levels of computer systems are improved.

As the software systems with which large volume of data can be processed under a high speed and for which the maintenance is easy, process data processing package (PDS) has been arranged in a series. With this, data base software processing is improved, and CRT image processing and various report printing processes are greatly improved.

Various water and sewage softwares have been developed, and they are highly contributing to the enhancements of monitoring and control. Recently, importance of simulation technique is increasing, and plant analyzation and operating simulation and made at the time of design through the simulation technique. These softwares are arranged to be general purpose softwares in the form of a software package, and used widely for various water and sewage works. For example, they are used for normal and abnormal flow calculations in water channels, adjustment of water distribution, elimination of rain storm runoff, simulations of burning status of sludge burning furnaces, port and river contamination dispersion simulation, energy-saved operations of pump group, rapid water reduction analysis in the case of a failure in water supply and distribution system, etc.

As the importance of software increases, improvements of the software preparing productivity and reliability are urged, and for this reason, a supporting system for software developing is being operated.

As for the control algorithm, new control methods such as the optimum control method based on the modern control theory, status estimation by observer, optimum setting of control parameter by autotuning system and human like process control by reasoning in Fuzzy theory are applied to wide range water control, water distribution control, filteration plant control, pump control, central trunk line control, rain water intrusion preventing control, sludge treatment control, relay pumping station control, sludge dewater contorl, sludge burning control, etc. in the water and sewage works.

3.6 Electric technologies

As the power electronics and new material technologies are advanced, electric technologies are improved for achieving high reliability, maintenanceability, safety, circumferential fitness, reduction in size of equipment and energy saving.

SF_6 gas insulated switching gears and mold transformers are already used popularly. Including the components and control circuits, dimensions of the SF_6 gas insulated switching gears are minimized, and as a mini F pack, the developments are proceeded. With this development, size of the water intake/distributing equipment in the water and sewage works has been reduced and reliability has been improved.

As for the power inverters, VVVF inverter (FRENIC-2000) using power transistors and thyristor inverter (STANIC) are widely used for blower and pump speed controls.

Utilizing the wide area of water and sewage facilities, solar energy and sun light using technologies are examined.

3.7 Engineering technologies

Electric machineries and instrumentation systems for water and sewage works are delivered to the sites under the full turn-key system from the design and manufacturing to the delivery and operation. Recently, the scale and level of the systems are increased, and therefore, not only the design and manufacturing technologies but also, including the design and manufacturing technologies, importance of the engineering technologies has been increased.

Including the electric machineries, instrumentations and computers, total system process management, comprehensive system test, electric machinery and instrumentation constructions, civil engineering, on site adjustment with the machines, safety and sanitation, maintenance system, overall arrangement, etc. are gradually being systemized as an engineering technology. Conventionally, the engineering work was considered to be a supporting work. Actually, however, this is the most important section in the system operations, and it has become the important existence which decides the quality of a system.

IV. POSTSCRIPT

Water and sewage technologies have been changed by reflecting the time-to-time idea, and suggested various needs. On the other hand, electric machinery and instrumentation & control technologies have indicated the rapid advancement based on the electric technologies represented by the micro-electronics and power electronics, and have well followed the needs in the water and sewage works. With the outstanding electric machinery technologies, instrumentation & control technologies and system technologies accumulated through the long term experiences, Fuji Electric has responded to the reliability and request of the customers. We wish we will be able to assist the water and sewage worlds through the new electric machinery and instrumentation · control technologies continuously for the future.

TOPICS

TAIWAN, FONG SAN WATER TREATMENT PLANT CENTRAL MONITORING SYSTEM

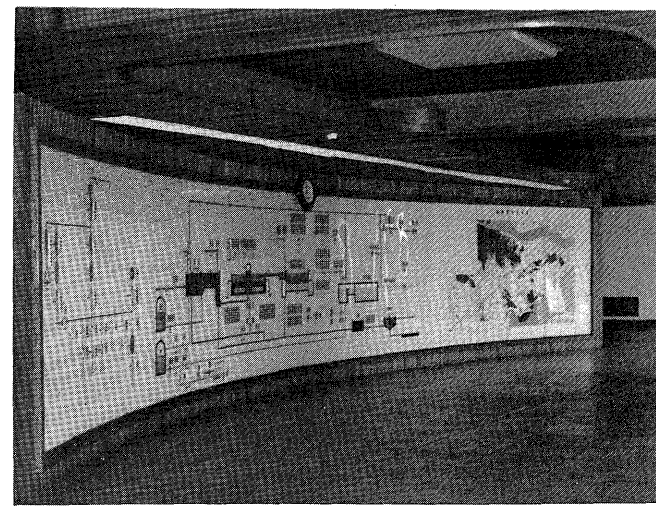
Fuji Electric recently delivered the computerized filteration plant central monitoring equipment as the first of this kind for water supply facilities in Taiwan.

The Fong San water treatment Plant managed by Taiwan water supply corp. is the main filteration plant for the Kaohsiung city, and capable of filtering 750,000 tons per day.

Subjective equipment of monitoring and control

Within the plant: Electric equipment room, filteration reservoir monitoring room, deposition reservoir control room, feed pumping room and water quality control room.

Outside equipment: Pressure monitoring points: 27 points
Pumping stations: 9 stations
Water distribution reservoirs: 2
Filteration plants: 2



Equipment delivered by Fuji Electric

For the above subjective equipment (both within the plant and outside), telemeter controllers were installed in 45 places. The telemeter controllers send data to the central control room, and with a computer, central monitoring control is performed.

Computer system: Central processor (u-400; 128kB) 1 set
CRT: 4 sets
Line printer/typewriter, etc.

Telemeter equipment
Large capacity type: 7 sets
Analog channels: 60 points
Supervision : 140 points
Small capacity type: 38 sets
Analog channels: 8 points
Supervision : 36 points

Back-up supervisory equipment
Microcontroller: 1 set
Typewriter: 1 set