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RECENT TECHNOLOGIES OF ELECTRICAL EQUIPMENT AND INSTRUMENTATION FOR WATER AND SEWAGE TREATMENT

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1. FOREWORD

Planned investment in water and sewage treatment is going on to maintain and improve urban functions towards the 21st century.

The second century of water treatment began in 1988 and has entered the high diffusion rate age and securing of lifeline, supply of safe and fine water, efficient maintenance management, and other new indexes from quantity to quality have been beaten out.

For sewage treatment, there is a feeling of an age of construction, such as improvement of the diffusion rate, countermeasures against flooding by rainwater, etc. However, large cities are faced with such essential problems as improvement of the functions of facilities, more efficient maintenance, etc.

On the other hand, noticeable progress has been made in power electronics technology, new materials technology, optical application technology, biotechnology, robot technology, etc. and safe, stable, and efficient operation of water and sewage treatment facilities by using these new technologies is demanded.

It is thought that another transition period is coming in this field. Computer and instrumentation technologies which meet the needs of water and sewage treatment are outlined here.

2. TREND OF THE WATER AND SEWAGE TREATMENT WORLD

2.1 Water treatment

In 1987, water and sewage treatment facilities in Japan attained a diffusion rate of 93.9%, but there are still many problems which must be solved.

As seen in the deliberations of the Livelihood Environment Committee, future water treatment policy will develop basic measures along the four lines: (1) strengthening of management base and completion of the maintenance management system, (2) securing of lifeline, (3) supply of safe and fine drinking water, and (4) revision of the differences in charges.

Regarding the lifeline for maintaining municipal functions, securing of water resources, fusion of water source and distribution, equal water supply during drought, base water supply during disasters, and other wide area water operation is planned.

Regarding safe and fine drinking water, water source and water supply quality supervision and forecasting, advanced water treatment, and appropriate injection control of chemicals are attracting attention. In particular, in 1988, local governments, which are tackling the problem of water quality, were prompted to introduce advanced water treatment by establishment of a national subsidy for the introduction of advanced treatment facilities.

Regarding maintenance management, effective use of facilities, preventive maintenance, advance maintenance, aging countermeasures, and improvement of functions are problems. More efficient business and rationalization of administrative management are planned through the application of the newest knowledge engineering and use of advanced information systems.

On the other hand, regarding water pipeline countermeasures as a new movement, establishment of a "Water Pipeline Technology Center", establishment of a Ministry of Welfare "Water Quality Control Bureau", planning for the "Aqua 100 Plan" for national waterworks, etc. are proceeding and powerful propulsion to affluent water treatment for the 21st century is planned.

2.2 Sewage treatment

Sewage treatment is an important infrastructure of cities with the role of improving the living environment, flooding prevention, and maintenance of the quality of public water areas, and is the most important problem even in the strong demand for social capital adjustment and consolidation.

In 1987, the diffusion rate of sewage treatment in Japan reached 39%. The target of the 6th five year plan for sewage treatment that began in 1986 is a diffusion rate of 46% and drainage rate of 44% in 1990 and shows a long-term concept which increases the diffusion rate to 70% in the year 2000. Looking at its contents, the diffusion rate is 85% for cities with a population of 1,000,000, but a low 6% for cities with a population of 50,000 or less.

Table 1 Technical trend of water and sewage treatment

Class	Topics	Computer and instrumentation technology
Common	Completion of facilities maintenance management system Efficient operation of facilities Facilities maintenance	Integrated supervisory and control system Knowledge engineering applied preventive maintenance system Mapping applied pipe information system Advanced information network system
	Facilities energy-saving Power conservation Resources conservation	Variable speed control of pumps and blowers Knowledge engineering applied (chemical injection/DO) control
	Improvement of facilities functions Aging countermeasures	Facilities modernization planning technology Digital supervisory and control system Fiber optics instrumentation system
	Suitable management of business More efficient business Improvement of public service	Business/window business support OA system Work station, LAN system
Water	Securing of lifeline Effective management of water Installation of communicating pipes between distribution systems Suitable restriction of water use Equal water supply Leakage prevention Disaster countermeasures	Wide area water management system Water distribution control system Water pressure adjustment system Distribution control system during drought Water leakage detection system Base water supply system
	Supply of safe and fine drinking water Water source quality supervision Production of fine drinking water	Water source monitor, robot for water quality analysis Advanced water treatment technology Knowledge engineering applied chemical injection control
Sewage	Improvement of diffusion rate Urban city sewage works consolidation Small scale sewage works consolidation	Small supervisory and control system New sewage treatment system (biofocus WT)
	Rainwater flooding countermeasures Solution of flooding in cities	Meteorological, rainfall, rivers information system Rain water discharge, flooding, time of flow solution technology Knowledge engineering applied rain water pump operation control
	Water quality maintenance Closed water area entrophy prevention Water quality environment standards	Advanced sewage treatment technology Total nitrogen meter, total phosphorous meter, ammonia meter Bio sensor
	Effective use of resources Sewer pipe Recycling of treated water Advanced use of sludge	Optical communications network Recycle system for public sewage Wide area sludge centralized supervisory and control system Fuel power plant technology, compost

The spread of sewage treatment to these medium and small cities and towns will be a problem in the future.

On the other hand, for large cities, besides improvement of the diffusion rate, changes in the metropolitan environment, increase of the amount of rainwater discharged due to improvement rate of paved streets, shortening of the time of flow, local concentration of downpours due to the heat island phenomena, and other metropolitan type flooding will increase and become a problem.

Moreover, to maintain the natural environment, the prevention of pollution, total reduction, and maintenance of the water quality of lakes and ponds by the early establishment of water quality environmental standards is demanded.

Recently, the use of facility space and the multipupose use of treated water and sludge have also become also become important problems from the standpoint of use of sewage works as a resource. Research and development of a new waste water treatment system (biofocus WT) using biotechnology is advancing as a new direction of sewage treatment.

Such water and sewage treatment policy problems and Fuji Electric technology which meets them are shown in *Table 1*.

3. TREND OF ELECTRICAL MACHINERY AND INSTRUMENTATION

The element technology making up the electrical machinery and instrumentation technology of water and sewage treatment plants is integrated system technology with technology regardless of electricity (E), instrumentation (I), and computer (C) as the vertical component and engineering from system design to implementation as the horizontal component. The effect of balancing and fusing these into one is large.

Fuji Electric intends to develop wide ranging technology which meets the needs of the water and sewage treatment world by its traditional "EIC integrated technology".

The computer-based operation management system, new optical instrumentation and water quality sensor and electrical technology are outlined here.

3.1 Computer

The personal computer, work station, microcomputer, and other kinds of computer hardware featuring intelligence, high-speed, small size, low price, and easy use have become popular. Even from the standpoint of software, image processing technology, artificial intelligence technology, diagnosis technology, and other technologies have advanced rapidly and application to the water and sewage treatment fields has by the use of these types and technologies has become active.

In the water and sewage treatment fields, in addition to the conventional hierarchical vertical distributed supervisory and control system, the horizontal distributed system which distributes functions by level is progressing and supervisory and control systems have recently shifted to a vertical and horizontal distributed system.

In this horizontal distributed system microcontrollers are distributed and installed for each function unit (display, recording, operation, storage, arithmetic and logical operation, control). These controllers and a high-level process computer are integrated through an LAN or other data transmission line. This allows a flexible system configuration matched to the scale, application, and introduction period of the plant and improvement of reliability by distributed installation and ease of preparation of software as a dedicated machine.

From the standpoint of operation, a system with touch operation from a screen using a multicolor high-density CRT has become popular. The advantage of this system is that to the operator, operation is performed while experiencing operation of the actual plant.

From the software standpoint, facilities operation and design support efficiency and reliability are improved by the development of forecasting technology, knowledge engineering technology, analysis technology, simulation technology, etc. The development of training simulation for the acquisition of operation technology has advanced.

On the other hand, the application of the microcomputer in this area is also flourishing for the maintenance management age and besides the conventional water and sewage treatment supervisory and control functions, systems which support facilities ledger management, water quality data management, pipeline data management, and other maintenance management business are being incorporated as computer system objective functions.

Recently, the range has widened to planning support system using mapping (pipe network computation simulation, system planning and cost estimation, sewage route planning), window business support system (water charge computation, water supply ledger, sewage works ledger), and other support systems.

In the future, from the standpoint of overall water and sewage treatment efficiency, optical fiber network coupling with a high-level business computer will also advance.

Fuji Electric is completing development of and offering for actual use the supervisory and control system FAINS-1000, 100 series and the FANSY system as a maintenance management and business support system which meet these needs.

3.2 Sensors

Whereas data processing technology has advanced rapidly, development efforts aimed at improved accuracy and easy maintenance of the sensors which are the data source are also continuing.

3.2.1 Optical fiber instrumentation system

Fuji Electric is the first in the world to complete serialization of a highly reliable optical fiber instrumentation system which transmits digital and optical signals from the site instead of conventional analog signal transmitters and has already started it practicalization as a new generation instrumentation system.

This system has been made intelligent by building a microcomputer into the sensor and transmits the output signal in time series as an optical digital signal. It is a highly reliable system that is theoretically strong against the lightning noise that was a problem with electric signal transmission.

By making both incoming and outgoing communication possible, it has complete power source and output signal self-diagnosis functions and remote zero adjustment and span adjustment functions and maintenance and inspection information can be grasped centrally and it is useful in sensor preventive maintenance and also has a large effect on daily patrol inspection work.

3.2.2 New automatic water quality analyzer

In the rise in concern for safe and fine drinking water, water quality measurement control technology is a field in which there is much more room for research and development than flow measurement technology. Even here there is a strong desire for improvement of the reliability and maintainability of water quality analyzers. On the other hand, the spread of water quality pollution of waterworks water sources has been accompanied by an increase in the components to be continuously

measured.

Fuji Electric has completed development of a total nitrogen meter, three components nitrogen meter, total phosphorous meter, and an ammonia meter which become the index of water quality environmental standards as a new series aimed at new automatic water quality analyzers which are very easy to use and maintain. These water quality meters feature simplification by ozonation of the conventionally complex analysis preprocessing process and as all weather type automatic analyzers. The maintenance period of the ammonia meter was extended substantially by making it the contractless liquid type.

Development of an robot for water quality analysis which is completely automated from sample handling preprocessing to water quality analysis and data tabulation to support laboratory water quality analyzers has been completed and is attracting attention.

3.2.3 Bio sensor

Development of a bio sensor using microorganisms, enzymes, and other organisms as a new water quality sensor field has begun. The measurement method combines measuring devices such as a film with fixed microorganisms. DO electrodes, etc. and promotes organisms as a chemical substance reaction and detects this reaction as an electrical signal by means of DO electrodes. Its development as an ammonia, BOD_5, organic acid, etc. water quality sensor is flourishing as one link of bio focus WT development and it is expected to be the next generation sensor. The bio sensor does not stop at water quality measurement, but can also be used in a wide range of fields in the future as a poison sensor which uses the characteristics of organisms.

3.3 Electric technology

3.3.1 Power substation facility

Power substation and emergency power generation facilities are aimed at high reliability, safety, easy maintenance, environmental resistance, smaller size, and energy saving and development from both the hardware standpoint and preventive and advance maintenance management software standpoint through the advance of power electronics and new materials.

The SF_6 gas insulated switching equipment of special high voltage substations has been made exhaustively compact in both weight and space. Fuji Electric planned development of this as C-GIS and for more higher reliability.

For high voltage substation facilities, safety is also increased by the use of vacuum breakers, moulded transformers, and other oiless devices and development of devices which are more compact and easier to maintain has progressed.

Regarding low voltage power facilities, a multifunction control center with drive circuit, sequence control function, and digital transmission function was developed and greater compactness and maintainability and shorter work time were planned. The increased capacity of power transistors has been accompanied by a widening of the range of application of the water and sewage treatment variable speed control inverter motor (FRENIC5000 series) up to about 300kW and low noise and low harmonics countermeasures and smaller size and improved maintainability were planned.

On the other hand, development of device deterioration technology and preventive maintenance technology has also become active, and large capacity oil transformer troubleshooting system, preventive maintenance system applying knowledge engineering to emergency power generating facility, substation facility power failure and recovery guidance support system, etc. are topics in this area.

3.2.2 Ozonizer

Regarding the ozone generator used in advanced water treatment, a high capacity ozone generator with good generation efficiency and which does not demand much installation space is required for practicalization. Fuji Electric has already serialized ozone generators with unit capacities of up to 30kg/h.

Recently, the development of highly efficient large reaction tanks to maintain ozone reaction at high efficiency has flourished and research on various technical conditions has been advanced by simulation technology using hydraulic models.

4. CONCLUSION

The wave of internationalization, informationalization, and the aging society is expected to become stronger toward the 21st century. Water and sewage works are no exception and the advance of technology will accelerate steadily. In the future also, the concept of the age will be reflected and customer trust and demands will be met by electrical equipment and instrumentation technologies which pursue needs and system technology accumulated through abundant experience. These will also serve the water works world through new electrical equipment and instrumentation technology.

Regarding the publication of the water system technology special issue, we wish to express our gratitude to the concerned parties of the water works world and ask for their guidance and support in the future.