Effective water use in Pipeline Operation Considering High Quality;

Epoch Project

Summary

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Japan Water Research Center

General Information on *Epoch Project*

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Epoch Project; Effective water use in Pipeline Operation Considering High Quality was conducted jointly by the industrial, governmental, and academic sectors focused on water pipeline systems for three years since fiscal 2002. Despite its extreme importance, research on pipeline used to be conducted separately by water supply utilities, companies, and universities. In ***Epoch Project***, the three sectors worked together and acquired many valuable research findings not hitherto available.

Pipeline systems, accounting for 60 to 70% of the total assets owned by water supply utilities, are now facing renewal. We are expected to construct appropriate pipeline systems for the future, at this time when massive renewal is needed. The results of research obtained in the project will provide extremely useful information.

For this project, Pipeline Research Committee was organized comprising five scholars, 11 water supply utilities, and 14 private companies. Three research groups were set up for different areas of the research. Research Group No.1 was set up for "Cause of the Occurrence of Impurities", Research Group No.2 for "Movement of Impurities and Hydraulic Generator in Pipeline," and Research Group No.3 for "Removal equipment for impurities." The research groups implemented their assigned research and held the Pipeline Research Committee meeting when necessary during the research period to promote comprehensive research on pipeline. The dedicated pipeline research produced much valuable information. The achievements of each research group will be introduced bellow.

Research Group No.1: Cause of the Occurrence of Impurities

As a basic survey on suspended solid in pipeline, Research Group No.1 conducted a questionnaire survey of water supply utilities. The characteristics of suspended solid, such as iron rust (red water causative substance), coating material scale, and sand, were clarified. According to the results of a survey on red water in existing pipelines, the locations and causes of occurrence were studied by experiments. Consequently, this group found that the density of suspended solid was normally high where suspended solid was generated and that this might lower water quality. Checking and systemizing the phenomena were found to enable risk evaluation of water-quality problems. To prevent suspended solid, the group also studied a method of making water non-corrosive by dosing calcium hydroxide and carbon dioxide gas and confirmed the effect of suppressing suspended solid occurrence and outflow.

Research Group No.2: Movement of Impurities and Hydraulic Generator in Pipeline

To check the behavior of suspended solid in pipeline, Research Group No.2 investigated the diffusion and deposition of various suspended solid using the experimental pipeline installed at the Kawai Purification Plant in Yokohama. The experiment on the diffusion and deposition of suspended solid (sand, coating material scale, etc.) in the experimental pipeline clarified the

moving start velocity of sand or coating material scale and also allowed an equation to be created for estimating the distribution of suspended solid at a branch. The distribution of suspended solid in a pipeline network, estimated using this equation, almost matched the experimental result. This is considered to have enabled efficient pipeline cleaning in the future. What should be mentioned in particular about the experiment is a new finding that suspended solid (sand) at the bottom of pipe at a branch demonstrated behavior not imagined using the conventional concept and easily moved toward the branch.

For effective use of unused energy, the research group conducted a field experiment on hydraulic power generator units with the cooperation of Public Enterprise Bureau of Saitama Prefectural Government and the town of Takane, Yamanashi Prefecture. By the two-year demonstration experiment on a small hydraulic turbine generator, the long-term performance of the turbine and the effect of its introduction could be verified. The "Manual for the Installation of Water Turbine Generator in Pipeline" could also be created for converting surplus pipeline pressure into electric power (exploitation of unused power). We hope that this will be useful for the effective use of energy in the future.

Research Group No.3: Removal equipment for impurities

Research Group No.3 conducted demonstration experiments on many suspended solid removal systems. By summarizing the features of these systems and considering the achievements of Research Group No.2, the group prepared a proposal on the optimal installation position of each system whereby each system demonstrates its maximum performance. The research group also developed an effective suspended solid removal system that requires minimum drain for pipeline cleaning (drainage of water for pipeline cleaning). The strainer system was found capable of removing sand, coating material scale and other comparatively large suspended solid and the membrane filtration system capable of removing rust and other fine suspended solid. In research for an undrained circulation removal system by combining the strainer system and membrane filtration system, the research group attempted to develop a mobile system capable of removing an extended range of suspended solid with almost undrain of water for pipeline cleaning. Testing on the experimental pipeline validated the system.

As generalized above, the project produced much information hitherto unavailable. The achievements of ***Epoch Project*** were partially published in Proceedings of the Water Supply Conference JWWA, Journal of Environmental Instrumentation Control and Automation (EICA), and the Proceedings of the Annual Academic Conference of the Japan Society of Civil Engineers (Division 7) as papers and widely released to the public.

As we can see from the project, pipeline research is profound. It is not too much to say that the research has just begun. If a city is compared to a human, we can consider a water pipeline system as an artery and recognize its importance in the case of disasters such the earthquakes, droughts, and pipeline accidents that are occurring these days. We again realized the necessity of further research and continuous efforts to keep waterworks as a safe and reliable system.

Taking this opportunity, we would like to express our gratitude last to the members of the committee and the staff of the secretariat for their efforts in carrying out the three-year project and also to those concerned for their unstinted cooperation.

Outline of Outcome of *Epoch Project*

Effective water use in Pipeline Operation Considering High Quality (*Epoch Project*)

Research Group 1

Research on the causes of suspended matter

I. Basic surveys on suspended matter in pipelines

①Survey on suspended matter

Suspended matter in pipelines can be classified into sand, iron rust (including fine particles causing red water), coatings, and water quality substances (manganese, etc.). Their basic properties (specific gravity, settling velocity, etc.) and behavior-related basic characteristics were investigated.

②Questionnaire survey on the causes of suspended matter

A questionnaire survey was conducted on about 90 water service agencies to obtain information on the causes (direct and indirect factors) of suspended matter in pipelines. Substances most complained of: **1. Iron rust (red water) 2. Coating 3. Sand.**

II. Experiments on causes of suspended matter

With the questionnaire data, experiments using a real pipeline and immersion system were conducted to clarify the causes of suspended matter.

①Experiment using an actual pipeline

An actual pipeline was investigated at block borders, pipe ends, and the locations where substances were deposited and where suspended matter was judged from the questionnaire data to occur easily. In such places susceptible to water suspension or water quality deterioration, the density of suspended solids was found always high. Analyzing and systemizing the phenomenon will enable the prediction of water quality problems in each pipeline.

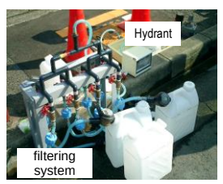


Photo: Sampling pipeline water

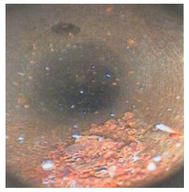


Photo: Survey with in-pipe

②Experiment on Langelier's index (Review of preventive maintenance measures)

The purpose was to clarify the mechanism of red water and to research techniques of preventing suspended matter. To review the injection of slaked lime and carbon dioxide gas aimed to improve Langelier's index of judging water corrosion, this test was conducted on water purified with slaked lime and carbon dioxide gas and ordinary purified water and the suspended matter suppression effect was investigated.

The injection improved very corrosive water to an ordinary level and suppressed the formation of calcium film and the occurrence and outflow of suspended matter.

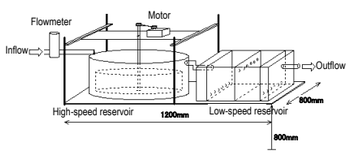


Fig.: Immersion system

Table：Samples used

№	Type		Condition	Length
1	Aged pipe	No CL	Very tuberculated	150mm（Appearance check） 50mm（Aging evaluation）
2			Not very tuberculated	150mm 50mm
3		CL*	Neutralized depth 1.5 to 2.5 mm	150mm 50mm
4			Neutralized depth 0.5 mm	150mm 50mm
5	New pipe	No CL	Shot-blast	150mm 50mm
6		CL	–	150mm 50mm
7			–	150mm 50mm
8		Powder-coated**	–	150mm 50mm

Research Group 2

Research on optimal pipeline network system and energy exploitation

I. Estimation of suspended matter diffusion/deposition in pipeline network

①Moving start velocity and settling speed of suspended matter

The flow velocities where sand, iron rust, and coating begin to move and stay were investigated with an experimental pipeline. (See the table below.)

Table Flow velocities where suspended matter starts moving and settles

Suspended matter	Moving start flow velocity	Settling flow velocity
Fine sand	0.2 (new pipe) to 0.3 (old pipe) m/s	About 0.3 m/s
Sand	0.4 (new pipe) to 0.5 (old pipe) m/s	About 0.4 m/s
Coating fragment	0.1 m/s	-

②Estimate equation for suspended matter distribution at branch

The suspended matter distribution ratios at branches (T and cross) were checked by varying the bore and flow velocity to obtain their estimate equations.

Coating → Suspended matter moving adrift in a pipeline is distributed by the flow ratio.

Sand (iron rust) → Suspended matter moving at the bottom tended to flow toward a branch. This tendency was confirmed by flow analysis using the general-purpose flow analysis software "FLUENT." (See the table and figure below.)

T branch bore	Branch shape	Estimate equation	Condition
φ150×φ150 φ100×φ100	B, C, A	Equation(1) $y = e^{-6.9(1-x)}$	Inflow velocity Va<1.5m/s
φ150×φ100	B, C, A	Equation(2) $y = \frac{1}{1+e^{(18.5-24.8x)}}$	Inflow velocity Va≦1.7m/s

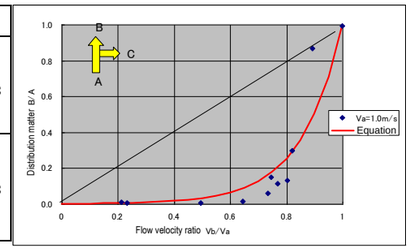


Fig.: T branch (φ150×φ150) medium sand

③Estimation of suspended matter diffusion/deposition in pipeline network

With information obtained in ① and ②, an experimental pipeline was used to see whether the equations are applicable to the estimation of suspended matter behavior.

The estimation and experimental results almost matched. By applying the results, we can conjecture where in a pipeline network where much suspended matter passes or is deposited. This will make pipe cleaning efficient.

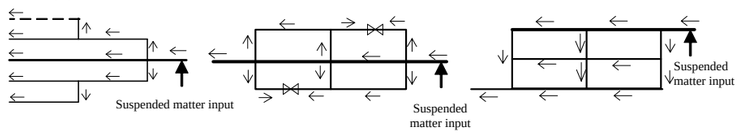


Fig.: pipeline・distribution network

II. Demonstration experiments on small power generation waterwheel

By field experiments of about two years at Showa Purification Plant, Saitama Bureau of Public Enterprise and in Takane, Hokuto City, Yamanashi, the long-term performance and introduction effect of a small power generation waterwheel were checked and good results were obtained. Based on the results of these experiments and a questionnaire survey conducted on about 230 agencies, "Introduction Manual for Waterwheel Power Generation Facilities for Installation in Pipeline" (separate volume) was created.

Research Group 3

Technical development for water quality improvement in pipelines

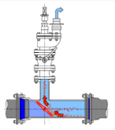
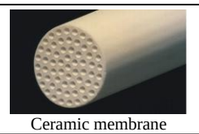
I. Development and evaluation of suspended matter removal systems

Of the "effective systems removing suspended matter from pipeline by minimum pipe cleaning water," ones judged to have an excellent investment effect and easy to introduce were brought in by participating companies and experimented in this project. Then particularly feasible systems were developed and evaluated.

II. Development of no-drain circulation removal system

A system was considered capable of covering all suspended matter in an existing pipeline by capturing sand, coating, and other comparatively large suspended matter with a strainer and rust and other fine suspended matter with a membrane filtration system. Therefore, a combined suspended matter removal system was developed and its performance was evaluated. To operate the system by reducing washing water, a method of circulating water in a section with no draining was studied.

Features of suspended matter removal systems

Suspended matter removal system	
Strainer	
Membrane	
Membrane	 Ceramic membrane
Non-suspension vertical tuberculation removal	
No-drain circulation removal