1. Introduction

Water leakage from pipes is caused by several reasons such as degradation, corrosion and breakage of water pipes due to traffic load. As water pipes maintain high water pressure, the amount of water leakage will increase rapidly if prevention measures are not taken. Accordingly, water leakage prevention is a critical measure to be taken in the water supply business.

Less leakage means less utilization of precious water resources and we can then offer a more stable water supply service. It also prevents excess amounts of water to be discharged into the water supply network, resulting in cost reductions. Furthermore, it also contributes to energy conservation and natural resource conservation thus the reduction of environmental load.

Fukuoka City started its water leakage prevention campaign seriously in 1956. The water leakage ratio at that time was 38.6%. (Fig-1) Water leakage was a critical issue to be solved as Fukuoka City did not have abundant water resources geographically. After starting the water leakage prevention campaign, the amount of leakage was progressively reduced. As a result, the leakage amount was reduced to less than 10% in 1982 and 2.6% nowadays. This is one of the lowest leakage ratios in Japan. On the other hand, the leakage ratio in major Asian cities is more or less 30%. It is around 10% even in industrial countries all over the world. As described, the water leakage prevention measure in Fukuoka City is a technology that we can be proud of.

Here, I will introduce you to the way we have achieved this significantly low water leakage ratio and how we have maintained it.

2. Water Leakage Prevention Measures

Fukuoka City has been taking prevention measures based on three types of measures shown in the Table-2.

(1) Basic measure

This is a fundamental leakage prevention measure by collecting and analysing data concerning leakage. Based on this analysis, effective leakage prevention planning is studied.

![Change of Leakage Ratio](image)

Table-1 Fukuoka City Waterworks

<table>
<thead>
<tr>
<th>Classification</th>
<th>Item</th>
</tr>
</thead>
<tbody>
<tr>
<td>Basic Measure</td>
<td>Survey (Effluent analysis, Leakage analysis)</td>
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<tr>
<td></td>
<td>Planning Study</td>
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<tr>
<td>Symptomatic Measure</td>
<td>Mobile Work</td>
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<tr>
<td></td>
<td>Planned Work (Leakage prevention research)</td>
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<tr>
<td>Preventive Measure</td>
<td>Replacement of aging service pipe</td>
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<td>Replacement and improvement of distribution pipe</td>
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<td></td>
<td>Water pressure adjustment by water supply adjustment system</td>
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</table>
(2) Symptomatic measure
Repair work will be done as soon as the leaking point is found. **The Mobile Work:*** onsite inspection and repair work will be done just after finding the leaking water on the surface or receiving a leakage report. In Fukuoka City, we secure staff to be ready for any leakage cases around the clock.

**The Planned Work (Leakage prevention inspection):** the potential water leak underground will be inspected and repaired according to a planned schedule. Some 800 to 1000 water leakage points have been found every year by skilled staff through sounding leaking noise or using a leak detector. (Photo-1)

Currently, around 2,900 km of the water supply network has been inspected annually which is almost 74% of total length of the water supply network of around 3,900 km in Fukuoka City. Places to be inspected will be determined based on past records of leakage, water pressure as well as data concerning corrosive soil characteristics.

In addition, Fukuoka City established a Waterworks Technology Training Institute in 2001 to take initiative to transfer waterworks technology. In this institute, they are working hard to maintain and enhance skills for water leakage prevention by conducting “Leak inspection simulations” and “Flow rate measuring training”.

(3) Preventive measure
Measures to be taken to prevent water leakage from occurring:

For this purpose, Fukuoka City implements the following activities, such as replacing aging water service pipes, upgrading and improving water distribution pipes, controlling water pressure with the water distribution management system and other measures.

① Replacement of aging water supply pipes
Around 90% of leakage cases are from water service pipes (water pipes to supply water to individual households connected to water distribution pipes). (Figure-2) Although water supply pipes are owned by the water consumer, our waterworks bureau executes emergency measures to stop unintended water leakage up to the water meter and changes extremely aged water pipes with new ones at its own expense. Especially, lead water pipes, which tend to cause water leakage much more frequently compared with currently used polyethylene pipes, are given an intensive priority for replacement.
② Upgrading and improving water distribution pipes

A water distribution pipe overhaul project to replace aged water distribution pipes and other related works has been implemented systematically since 1965. This project focuses on reducing the amount of water leakage as well as improving water supply quality by such measures as reducing cases of rusty water and low water pressure. Especially, replacing all asbestos cement pipes, which cause many water leakage incident cases, during the period 1977 through 2002, considerably contributed to reducing the amount of water leakage.

Currently, the distribution pipes replacement work has been implemented to the extent of about 30km annually (0.8% of total distribution pipe network extension). The distribution pipes are ductile cast-iron pipes, which have splendid strength characteristics, and are covered with a polyethylene sleeve to prevent corrosion.

③ Water pressure control by the water distribution management system

Because of the major water shortage in 1978, a water distribution management system was introduced to control water flow and water pressure covering the whole area of Fukuoka City. The water supply area is divided into 21 blocks and water pressure is controlled in each block on a real-time basis by operating an electric valve remotely while pressure gauges and flow meters installed in distribution pipes are being monitored around the clock.

The purposes of this system are:

- Reduction of water leakage by reducing excess water pressure.
- Early detection of abnormalities of water distribution and execution of countermeasures at an early stage by remote-control operation.
- Implementation of impartial water supply unaffected by topographical elevation differences through water flow rate control among water treatment plants (transferring water supply amount each other)

As mentioned above, the water distribution management system contributes to the effective use of water resources and efficient water transportation considerably.

Under the current circumstances, the water control center is relocating to improve its aseismic capability and the water distribution management system also is upgrading on this occasion. The new system will be in operation in March 2013. Because of the faster data processing capability and the larger storage capacity, the operation performance for monitoring and controlling as well as system credibility will be improved.
3. Closing remarks

Water shortages associated with the increasing world population and global climate change are a matter of worldwide concern. In order not to waste our limited available water resources, the implementation of water leakage prevention measures will be an urgent issue in the future.

On the other hand, in order to implement water leakage prevention measures, considerable cost and time is required. For its implementation, consideration of the situation surrounding water supply business operators, such as the social environment regarding water supply, the natural environment, suitable technologies, financial conditions and other factors, are needed. It will be my great pleasure if the activities in Fukuoka City introduced here will be helpful for you.